JUN 22 1938

Vol. 65 JUNE, 1938 No. 6

Bulletin

of the

Torrey Botanical Club

Editor
R. P. Wodehouse

Associate Editors
Bernard O. Dodge
Henry Allan Gleason
Tracy Elliot Hazen
Michael Levine
George M. Reed
John W. Shive

CONTENTS

The American species of Dryopteris, subgenus Meniscium ..... *William R. Maxon and C. V. Morton* 347

The taxonomy of a community of blue-green algae in a Minnesota pond ..... *Helen Foot Buell* 377

The cactaceae of southern Utah ..... *Elzada U. Clover* 397

Response of sorghum to high and low soil moisture . *V. Panduranga Rao* 413

Index to American Botanical Literature 421

Published for the Club monthly except
July, August, and September
by
GEORGE BANTA PUBLISHING COMPANY, MENASHA, WISCONSIN
Subscription price $4.00 per year
Entered as Second Class Matter at the Post Office at Menasha, Wisconsin
Accepted for mailing at special rate of postage provided for in the act of February 28, 1925, embodied in paragraph 4, section 412, P. L. and R., authorized July 23, 1928.

THE TORREY BOTANICAL CLUB

President
RAYMOND H. TORREY

Vice-Presidents
ALFRED GUNDERSEN, Docteur de l'Université (Paris)
MRS. GLADYS P. ANDERSON, B.S.

Corresponding Secretary
JOHN S. KARLING, PH.D.
Schermerhorn Hall, Columbia University, New York, N.Y.

Recording Secretary
MISS FLORENCE CLYDE CHANDLER, A.M.

Treasurer
HAROLD N. MOLDENKE, PH.D.
New York Botanical Garden, Bronx Park, New York, N.Y.

Editor
R. P. WODEHOUSE, PH.D.

Bibliographer
MRS. MARGUERITE B. FULLING

Business Manager
MICHAEL LEVINE, PH.D.

MEETINGS

Meetings twice each month from October to May, inclusive: the first Tuesday at 8:15 P.M., at the American Museum of Natural History or at Columbia University; the third Wednesday at 3:30 P.M., in the Museum Building of the New York Botanical Garden, Bronx Park, New York, N.Y.

PUBLICATIONS

All subscriptions and other business communications relating to the publications of the Club should be addressed to the Treasurer, Dr. H. N. Moldenke (mail address, New York Botanical Garden, Bronx Park, New York, N.Y.). Matters relating to advertisements and circulation should be referred to Dr. Michael Levine, Montefiore Hospital, New York, N.Y. All communications regarding exchanges should be referred to the Corresponding Secretary, who is Chairman of the Exchange Committee on Publications.

Bulletin. Established 1870. Monthly, except during July, August, and September. Price, $6.00 a year; single numbers 75 cents. Of former volumes, only 24-56 can be supplied separately; certain numbers of other volumes are available, but the entire stock of some numbers has been reserved for the completion of sets. Manuscripts intended for publication in the BULLETIN should be addressed to Dr. R. P. Wodehouse, 75 Ridge Drive, Yonkers, N.Y. The editors may accept papers up to 20 pages in length, with illustrations and tabular matter generally not exceeding twenty per cent of that amount. Longer and more copiously illustrated papers, however, may be published if the excess pages, illustrations, and tabular matter are paid for by the contributors. Claims for missing numbers should be made to the Treasurer within 60 days following their date of mailing. The Treasurer will supply missing numbers free only when they have been lost in the mails.

Torreya. Bimonthly, established 1901. Price, $1.00 a year. Manuscripts intended for publication in TORREYA should be addressed to Mr. George T. Hastings, Editor, 2587 Sedgwick Ave., New York, N.Y.

Memoirs. Occasional, established 1889.

Preliminary Catalogue of Anthophyta and Pteridophyta within 100 miles of New York City, 1888. Price, $1.00.

Reprints. Contributors of articles accepted for publication in the BULLETIN should order reprints, if desired, when they return galley proofs to the editor. They may be ordered through the editor from the George Banta Publishing Company, the contributor paying for all his reprints. A schedule of rates is sent with galley proof.

The American Species of Dryopteris, subgenus Meniscium[1]

WILLIAM R. MAXON AND C. V. MORTON

(WITH PLATES 11–14)

With the exception of the subgenus *Meniscium* the American ferns of the genus *Dryopteris* were treated monographically by Christensen in 1907, 1913, and 1920. His work upon this difficult group, which had been distinguished (even among the ferns) for its widely overlapping and confused specific concepts and its exceedingly complicated synonymy, was based upon an enormous amount of material brought together from the larger European herbaria and the U. S. National Museum, and is of outstanding importance and permanent value. *Meniscium* was omitted because the series of specimens at hand was not sufficiently comprehensive.

That a revision of *Meniscium* is still sorely needed was brought home to us forcefully in a recent effort to identify an interesting Ecuador specimen collected by Mrs. Ynes Mexía, and the present paper has resulted from an effort to reduce the existing confusion. For the loan of much recent and valuable material we are indebted to the following institutions: Botanisches Museum, Berlin; Botanisk Museum, Copenhagen; Field Museum of Natural History; Gray Herbarium of Harvard University; Royal Botanic Gardens, Kew; New York Botanical Garden.

The first knowledge of a fern of this group comes from Plumier,[2] who in 1693 gave a description and plate of a plant called *Filix latifolia, non ramosa nigris tuberculis pulverulenta*. The same plate (with a slightly amplified description) was reproduced by him in 1705[3] under the name *Lingua cervina nigris tuberculis pulverulenta*. A little later Petiver[4] depicted the same species under the name *Phyllitis ramosa striis undulatis*. From the nomenclatural point of view, the first species to be proposed was that described by Linnaeus[5] as *Polypodium reticulatum*, his description reading as follows: "*P. frond. pinnatis oblongis integris, anastomosantibus rectangulis, punctis rectangulis approximatis. Plum. t. 9.*"

Later, Jacquin[6] described from Martinique a species which he called *Asplenium sorbifolium*, citing the same Plumier plate that formed the basis

[1] Published by permission of the Secretary of the Smithsonian Institution.

[2] Description des Plantes de l'Amérique 6. *pl. 9.* 1693.

[3] Traité des Fougères de l'Amérique 92. *pl. 110.* 1705.

[4] Pteridographia Americana *pl. 7, fig. 1.* 1712.

[5] Syst. Nat. ed. 10, **2**: 1325. 1759.

[6] Coll. Bot. **2**: 106. *pl. 3, fig. 2.* 1788.

[THE BULLETIN FOR MAY (**65**: 267–345) WAS ISSUED MAY 18, 1938]

of *Polypodium reticulatum* L. Jacquin's own description and figure leave no doubt that his species is identical with that of Linnaeus, a fact duly recognized by Schreber[7] in proposing the genus *Meniscium*. His description is as follows: "*Meniscium Schreb. Asplenium Jacq. Coll. 2 t. 3. f. 2 Polypodium reticulatum L. Capsulae congestae in lunulas, venulis frondis interjectis.*" The type species of *Meniscium* is therefore *Polypodium reticulatum* L.

The genus *Meniscium* was promptly accepted and its validity was not questioned for nearly 70 years. It was still recognized by Mettenius in 1856,[8] but in 1859[9] he reversed his earlier opinion and united it with *Phegopteris*, a procedure entirely contrary to our modern ideas of nomenclature, inasmuch as *Phegopteris* dates, as a genus, only from 1852. In any case Mettenius' systematic views were not shared by Hooker and Baker, who continued to recognize the genus *Meniscium*, a usage which occasionally continued as late as 1910. A union of this group of species with *Nephrodium* was proposed by Keyserling[10] and accepted by Diels.[11] Transfers to *Dryopteris* were first made by Urban[12] and were continued by Christensen in the Index Filicum.

Within the genus *Dryopteris*, the subgenus *Meniscium* is most closely related to *Goniopteris* section *Microdictyon*, which includes *D. Poiteana* (Bory) Urban, *D. Liebmanni* Maxon & Morton,[13] and *D. Ghiesbreghtii* (Linden) C. Chr. These species all have essentially meniscioid venation, but are distinguished from true *Meniscium* by their paired sori, which have the receptacle more or less elevated and rotund, never elongate. Such sori are not found in *Meniscium* except sporadically and, presumably, as an atavistic condition. Moreover, all species of *Goniopteris* have stellate hairs, at least on the rhizome scales, but these have not been found in *Meniscium*, except in *D. Desvauxii* forma *glandulosa*, in which a very few large multiradiate hairs are on close examination occasionally to be seen near the base of the costules.

An affinity with the subgenus *Stigmatopteris* is also evident through the aberrant species *D. Christii* C. Chr., which was described by Baker as *Meniscium opacum*. Here the venation is meniscioid and the receptacle

[7] Linnaeus, Gen. Plant. ed. 8, **2**: 757. 1791.
[8] Filices Lechlerianae, part 1. 1856.
[9] Op. cit. part 2. 1859.
[10] Polypod. Cyath. Herb. Bung. 1873.
[11] Die Natürlichen Pflanzenfam. **1**: pt. 4. 1899.
[12] Symb. Antill. **4**: 1903.
[13] **Dryopteris Liebmanni** Maxon & Morton, nom. nov.
Polypodium meniscioides Liebm. Dansk. Vid. Selsk. Skrift. V. **1**: 211. 1849.
Dryopteris meniscioides C. Chr. Ind. Fil. 277. 1905, not Kuntze (1891).

elongate, but the nearer relationship with *Stigmatopteris* is evident in the glabrous lamina, which is regularly pinnatifid at apex, rather than imparipinnate, and in the presence of scales along the costules. In *Meniscium* scales along the costae and costules are never found. Even along the rachis and stipe they are usually caducous.

The Old World species which have been referred to *Meniscium* are considerably different from any American species and are, as Christensen[14] suggested, probably not to be associated in the same subgenus with them.

The first comprehensive account of *Meniscium* was by Fée,[15] who listed 15 species, seven of which were new. He divided the species into two sections, one strictly Old World, characterized by having the sporangium-sac setose, the other, entirely American, with non-setose sporangium-sac. The American species were in turn divided into two groups, one characterized by hirsute sori, the other by glabrous sori. Fée's keen discernment of these critical differences was unjustly ignored by subsequent fern students. The hirsute character of the sori of certain species is usually obvious, even on casual inspection. A closer examination shows that the setiform hairs arise, not from the receptacle, but from the sporangium stalks near their apex. These we believe to afford an important character, separating the species into natural groups. The species proposed by Fée are mostly valid, although some of his names are antedated by those of other authors.

In determining the presence or absence of setae on the stalks of the sporangia a close scrutiny with the higher power of a dissecting microscope is often necessary, although in *Dryopteris Hostmanni*, *D. permollis*, and *D. Desvauxii* the setae are usually clearly visible with a hand lens or even with the naked eye. In counting the number of areoles and the number of lateral veins within a space of three centimeters we have selected the middle or lower portion of middle or lower pinnae of mature plants, inasmuch as the areoles are naturally fewer and the veins closer together near the apex of the pinnae, and of course the same condition is found in upper or juvenile pinnae.

The following account is far from satisfactory, owing partly to the lack of complete material suitable for comparison, the fronds as a rule being coarse and ill-suited to collecting in their entirety. In particular, a number of critical specimens from Bolivia have necessarily been left unplaced. Certain species also, like *D. Jurgensenii* and *D. Desvauxii*, are remarkably variable in size and general appearance. On the whole, however, the species are more readily recognizable than is indicated by the key. Their

[14] Monogr. Dryopteris 1: 268. 1913.

[15] Gen. Fil. 221–225. 1852.

number is almost certain to be increased, when additional material from Bolivia and several other regions becomes available for study.

KEY TO SPECIES

Fronds simple

Blades large (up to 60 cm. long and 12.5 cm. broad), acuminate, the midrib appressed-pubescent; stipes dull, puberulent, palaeceous; areoles 30–40-seriate; sori linear, nearly straight ..... 15. *D. simplicifrons*

Blades small (up to 12.5 cm. long and 4 cm. broad), caudate-acuminate, the midrib glabrous; stipes lustrous, glabrous, naked ..... 4. *D. minuscula*

Fronds pinnate

Pinnae uncinate-serrate, at least toward apex.

Upper pinnae often reduced; pinnae gradually attenuate from a broad base, mostly stalked, the uppermost sessile; veins and usually the leaf tissue strongly pubescent ..... 5. *D. serrata*

Upper pinnae not reduced; pinnae very narrowly oblong, rather abruptly acuminate-caudate at apex, mostly sessile, several of the uppermost semiadnate to short-decurrent; veins and leaf tissue glabrous ..... 6. *D. consobrina*

Pinnae undulate, crenulate, or usually subentire.

Stalk of sporangium without hairs.

Pinnae 2–5-jugate.

Blades conform; pinnae 4.5–7.5 cm. broad; lateral veins of fertile pinnae 4–11 pairs per 3 cm.; areoles 13–20-seriate.

Pinnae rounded, obtuse, or broadly cuneate at base, subsessile; lateral veins 8–11 pairs per 3 cm.; sporangia aggregate in single linear sori ..... 2. *D. Andreana*

Pinnae cuneate, the lower ones strongly so, stalked (up to 2.5 cm.); lateral veins 4–6 pairs per 3 cm.; sporangia often arranged in paired sori ..... 1. *D. lingulata*

Blades subdimorphic; pinnae 2.5–4.5 cm. broad; lateral veins of fertile pinnae 13–18 pairs per 3 cm.; areoles 7–10-seriate ..... 3. *D. arcana*

Pinnae many-jugate.

Areoles of sterile pinnae almost as long as broad, the secondary veins nearly straight. Pinnae linear, often falcate.

Pinnae entirely glabrous, the lower ones subcordate, sessile ..... 10. *D. ensiformis*

Pinnae hairy on veins, the lower ones cuneate at base, long-petiolate ..... 11. *D. Jurgensenii*

Areoles of sterile pinnae much shorter than broad, the secondary veins curving and arcuate, subsigmoid.

Sterile pinnae up to 22 cm. long and 3 cm. broad; lateral veins of fertile pinnae 12–18 pairs per 3 cm. (except in *D. nesiotica*); areoles 4–12-seriate; fertile pinnae contracted and much smaller than the sterile, except sometimes in *D. Salzmanni*.

Sterile pinnae 1–2 (2.3) cm. broad, subequally cuneate at base, mostly stalked, the basal ones strongly so; areoles 4–8-seriate. Lateral veins of sterile pinnae 11–18 pairs per 3 cm.; pinnae long-attenuate ..... 12. *D. angustifolia*

Sterile pinnae 1.7–3 cm. broad, obtuse or rounded at base, or oblique at upper side, sessile; areoles 8–12-seriate.

Pinnae long-attenuate; lateral veins of fertile pinnae 8 pairs per 3 cm. ..... 13. *D. nesiotica*

Pinnae acute or short-acuminate; lateral veins of fertile pinnae 12–16 pairs per 3 cm. ..... 7. *D. Salzmanni*

Sterile pinnae often over 30 cm. long, 3.5–6.5 cm. broad, long-acuminate; lateral veins of fertile pinnae 7–10 pairs per 3 cm.; areoles 13–22-seriate; fertile pinnae usually conform with sterile.

Pinnae broadest at middle ..... 8. *D. turrialbae*

Pinnae broadest in lower third ..... 9. *D. reticulata*

Stalk of sporangium bearing near apex 1 or more sharply pointed setae (obvious as hairs among the sporangia) or (in *D. Desvauxii* f. *glandulosa*) these rarely with a blunt glandular apex.
Blades subdimorphic, the fertile pinnae suffused with sporangia; sterile pinnae much larger (mostly 5–7 cm. broad).
Pinnae few, subentire ..... 21. *D. chrysodioides*
Pinnae numerous, the fertile ones deeply crenate to irregularly repand-crenate; plants much larger ..... 21a. *D. chrysodioides* var. *goyazensis*
Blades not dimorphic, the fertile pinnae usually with discrete sori; sterile pinnae commonly less than 4 cm. broad (up to 6 cm. in *D. membranacea*).
Areoles 3–5-seriate; pinnae rounded-auriculate at base, slightly constricted above base 14. *D. dispar*
Areoles 7–20-seriate; pinnae not auriculate, not constricted above base
Lower pinnae rounded at base, sessile or nearly so; areoles 11–20-seriate.
Pinnae caudate-acuminate, 4–6 cm. broad; sterile areoles commonly rounded; lateral veins of fertile pinnae 6 or 7 pairs per 3 cm. ..... 16. *D. membranacea*
Pinnae acute or attenuate, 2.5–4 cm. broad; sterile areoles acute; lateral veins of fertile pinnae 13–15 pairs per 3 cm. ..... 17. *D. Standleyi*
Lower pinnae cuneate at base, petiolulate; areoles 5–12-(rarely 15-) seriate.
Leaf surface almost invariably glabrous between the veins. Pinnae narrow (2 cm. broad or less); areoles 7–9-seriate ..... 18. *D. Hostmanni*
Leaf surface hairy, often densely and softly so, or the hairs replaced by capitate glands.
Pinnae large (usually over 20 cm. long and 3 cm. broad), the lowest with a petiolule at least 1 cm. long.
Leaf hairs conspicuous, setiform ..... 19. *D. Desvauxii*
Leaf hairs replaced by capitate glands ..... 19a. *D. Desvauxii* f. *glandulosa*
Pinnae smaller, the lowest with a petiolule not more than 5 mm. long. Leaf surface densely pilose ..... 20. *D. permollis*

1. DRYOPTERIS LINGULATA C. Chr. Dansk. Vid. Selsk. Skrift. VII. Naturv. Afd. **10**[2]: 271. 1913.

In this species the arcuate venules are often sterile at the middle and thus have a pair of sori, instead of a single linear sorus. This condition is occasionally noted in other species also and can not be considered as of special significance, except perhaps as indicating that *D. lingulata* is one of the more primitive species of this alliance. The paired sori are always elongate, and never have a definite rotund receptacle as in *Goniopteris* or in some of the Old World species that have been referred to *Meniscium*.

We have examined the following specimens:

COSTA RICA: Valley of Río Hondo, near Madre de Diós, in forest, alt. 200 meters, *Pittier* 10349, type coll. (US). Hamburg Finca, on Río Reventazón below Cairo, Prov. Limón, alt. 55 meters, in wet forest, *Standley & Valerio* 48659 (US). Finca Hundrisser, *Brade* 306 (Y).

PANAMA: Foothills of Garagará, Sambu Basin, southern Darien, alt. 30–500 meters, *Pittier* 5596 (US).

COLOMBIA: Tutenendo, 20 km. north of Quibdó, Intendencia del Chocó,

alt. 80 meters, *Archer* 2130 (US). Landázuri region, Dept. Santander, alt. 300 meters, along streams, *Mrs. Geo. L. Green* 51 (US).

PERU: San Antonio, on Río Itaya, Dept. Loreto, alt. 110 meters, in dense forest, *Killip & Smith* 29378 (US.)

2. DRYOPTERIS ANDREANA (Sod.) C. Chr. Ind. Fil. 252. 1905.

Meniscium Andreanum Sod. Recens. 71. 1883; Crypt. Vasc. Quit. 392. 1893.
Phegopteris Andreana Christ in Pitt. Prim. Fl. Costar. **3**: 35. 1901, as to name.
Dryopteris Andreana var. *glabra* Hieron. Hedwigia **46**: 352. 1907.

Founded on specimens collected along the Río Toachí, near Santo Domingo, Ecuador, and known to us only from that country.

Undoubtedly *D. Andreana* is most closely related to *D. lingulata* C. Chr., which is of very similar aspect but may be distinguished by the cuneate-based petiolulate lower pinnae, those of *D. Andreana* being rounded and sessile. We consider this an important character in *Meniscium*. The Costa Rican record for *D. Andreana*, published by Christ, was based on *Pittier* 10349, a collection which later served as the type of *D. lingulata*.

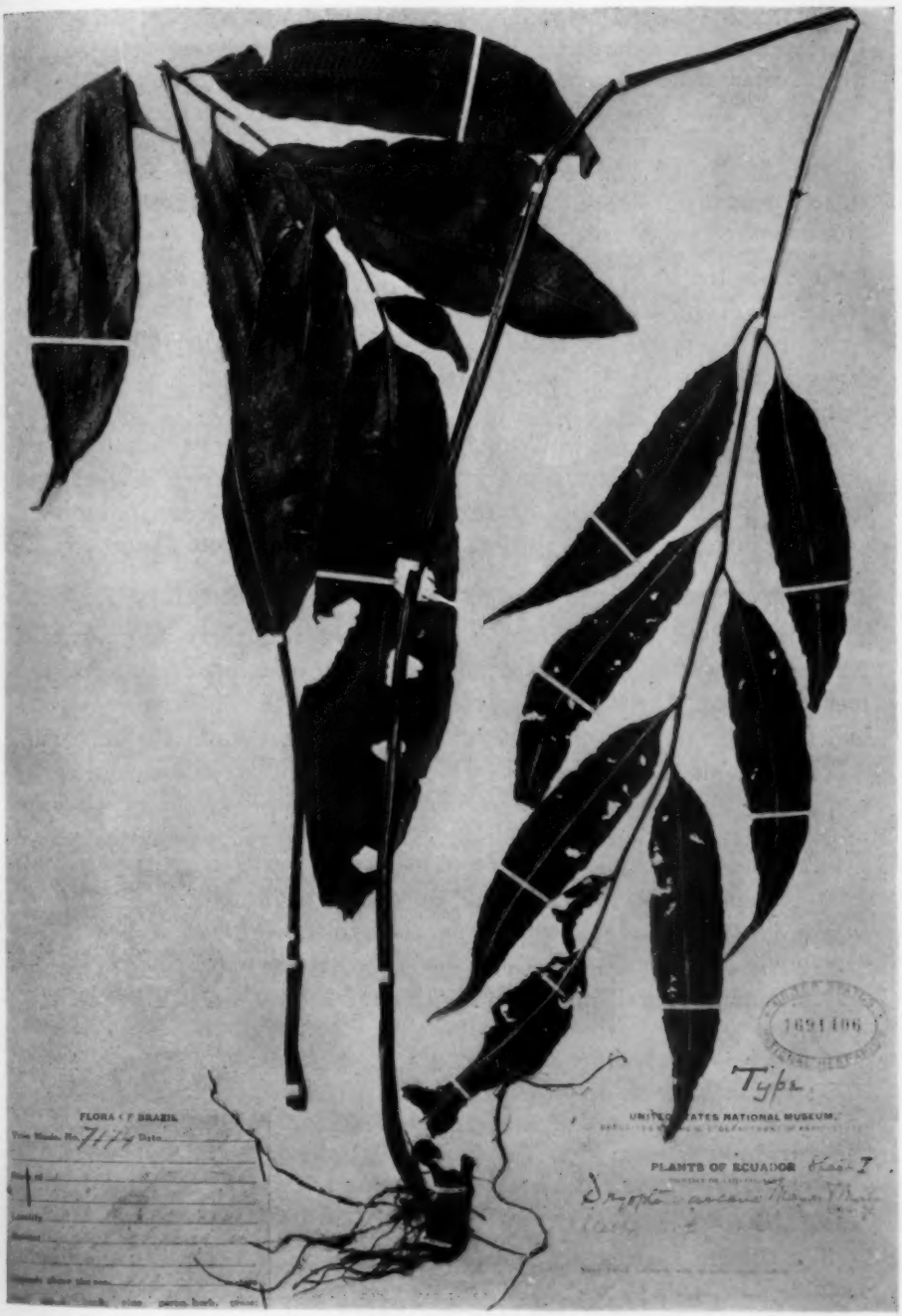
ECUADOR: In silv. apud Los Colorados, Oct. 1883, *Sodiro* (K, 3 sheets). In silv. reg. Angamarca, Nov. 1900, *Sodiro* 310 (Y, 3 sheets). In silv. trop. sec. fl. Pilatón, 1899, *Sodiro* (Y). In silv. trop. et subtrop., alt. 400–1800 m., *Sodiro* (US). Base of Mt. Chimborazo, alt. 900 m., July 1860, *Spruce* 5739 (K). Near Mindo, *Stübel* 767 (B, type of *D. Andreana* var. *glabra*). Nanegal, *Sodiro* 54/6 (K). Road from Quito to Manaby, *Sodiro* 54/8 (K).

3. **Dryopteris arcana** Maxon & Morton, sp. nov. PLATE 11

Rhizoma breviter repens, vix 1 cm. diam. Folia usque ad 85 cm. longa, laxe suberecta, subbiformia, omnino glabra, stipitibus e basi fusca dilute olivaceis sulcatis, eis foliorum sterilium laminas subaequantibus, eis fertilium quam laminis multo longioribus; lamina 1-pinnata; pinnae 2 vel 3-jugae et terminalis conformis major, infimae plerumque subopositae, ceterae alternae et remotae. Laminae steriles ambitu orbiculari-ovatae, 18–30 cm. longae, 14–20 cm. latae, rachi tenui; pinnae obliquae, margine subintegrae, auguste oblongae, 10–18 cm. longae, 2.5–4.5 cm. latae, apice longe acuminatae, basi subanguste cuneatae, infimae petiolulatae (3–9 mm.); venae laterales ca. 50-jugae, spatio 3 cm. 10–13, sub angulo 60° egredientes, prominulae; venulae sub angulo 45° eductae, angulo recto vel subacuto conjunctae, subtus promin-

Explanation of Plate 11

Plate 11. *Dryopteris arcana* Maxon & Morton, sp. nov. The type specimen; Ecuador, *Mexia* 7174. About half natural size.



MAXON & MORTON: DRYOPTERIS

ulae; areolae 7–10-seriatae, venulis excurrentibus elongatis liberis; parenchyma chartacea. Laminae fertiles ovatae vel oblongae; pinnae porrectae, margine irregulariter repando-crenatae, plerumque lanceolatae, 7–12 cm. longae, 1.5–2.5 cm. latae, in apicem caudatum sensim attenuatae, basi anguste cuneatae, plerumque breviter petiolulatae (infimae usque ad 1 cm.); venae laterales spatio 3 cm. 13–18, subflexuosae; venulae sub angulo lato egredientes, arcuatim conjunctae; areolae 8–10-seriatae, breves, plerumque fertiles; sori oblongi, brunnei, discreti sed vetuste interdum subconfluentes.

Type in the U. S. National Herbarium, no. 1,691,406, collected on the trail from Tena to Napo, Province of Napo-Pastaza, Ecuador, at an altitude of 400 meters, on a steep wet bank in shade, April 5, 1935, by Mrs. Ynes Mexía (no. 7174). Two additional specimens of this number have furnished data for the description.

Dryopteris arcana is not closely related to the other pinnate species, but shows an undoubted affinity with *D. minuscula*, despite the simple fronds of the latter. The veins diverge at a much wider angle, however, and the pinnae are not abruptly caudate, as is the blade of *D. minuscula*.

4. Dryopteris minuscula Maxon, Kew Bull. Misc. Inf. **1932**: 135. 1932.

This species, evidently rare, is known only from the type material at Kew, which was found by Lehmann (no. 4433) on moist earth banks and rock walls along the Río Dagua, coastal region of Buena Ventura, Colombia. It is by no means closely related to *D. simplicifrons*, the only other species with simple fronds, from which it differs in aspect, size, and gross morphology too widely for comparison, as well as in its non-appendiculate sporangia. Its relationship is doubtless with *D. arcana*, as mentioned.

5. Dryopteris serrata (Cav.) C. Chr. Ind. Fil. 291. 1905.

Meniscium serratum Cav. Descr. Pl. 548. 1803.
Meniscium dentatum Presl, Del. Prag. **1**: 162. 1822.
Meniscium palustre Raddi, Opusc. Sci. Bol. **3**: 284. 1819; Pl. Bras. **1**: 9. *pl. 20*. 1825.
Meniscium rostratum Fée, Gen. Fil. 224. *pl. 18 B, fig. 3*. 1852.
Phegopteris palustris Mett. Fil. Lechl. **2**: 24. 1859.
Phegopteris serrata Mett. Ann. Sci. Nat. V. Bot. **2**: 243. 1864.
Nephrodium serratum Keys. Pol. Cyath. Herb. Bung. 49. 1873.
Dryopteris reticulata var. *serrata* Farwell, Amer. Midl. Nat. **12**: 292. 1931.
Thelypteris serrata Alston, Kew Bull. Misc. Inf. **1932**: 309. 1932.

The present species, described originally from Habana, is exceedingly variable, but, though widely distributed, it gives no evidence of regional segregation. A distinctive character is found in the margins, which, at least near the apex of the pinnae, are uncinate-serrate. From *D. consobrina*,

the only other species with similar margins, *D. serrata* is distinguished by the key characters. Occasionally the margins are deeply jagged and erose-serrate. In certain other species of *Meniscium* the margins are often crenate or crenulate, especially in the fertile pinnae, but only in this species and *D. consobrina* are they ever truly serrate. Sometimes also, as in other species, minutely paleaceous buds are borne on the costae of the lower pinnae, at or just above their base. These occasionally develop into small plants. An extreme case is shown by a frond from Morro das Pedras, State of São Paulo, Brazil, *Brade* (Y), in which the young plants are 15 cm. high.

As to range: *D. serrata* occurs in Florida, but is uncommon in the West Indies, except in Trinidad; on the continent it ranges from Mexico to Paraguay and Argentina, being abundant in Brazil. Material of this species has mostly not been borrowed by us. The following list includes the numbered specimens examined, these mainly in the National Herbarium:

FLORIDA: Southern shore of Lake Okeechobee, *Harshberger* in 1912 (Y).

JAMAICA: *Wilson* 518; *Bot. Dept.* 332; *Sherring.*

CUBA: *Léon* 2404; *Hioram & Maurel* 4698.

PUERTO RICO: *Sintenis* 6378.

GUADELOUPE: *Duss* 1612.

TRINIDAD: *Fendler* 57 (9 sheets); *Britton, Hazen, & Freeman* 948; *Hart* 554; *Broadway* 2778; *Jenman; Kuntze.*

MEXICO: *Fisher* 35387; *Orcutt* 6628; *Purpus* 8602; *Ross* 1064; *C. L. Smith* 2111.

GUATEMALA: *Barber* 167; *Kellerman* 7360; *Lundell* 3297; *Maxon & Hay* 3056; *J. D. Smith* 2421.

HONDURAS: *Ames* 172; *Dyer* A 146; *Standley* 53701, 53784; *Thieme* (*J. D. Smith* 5660 and 5695); *Yuncker* 5049.

COSTA RICA: *Pittier* 10265; *J. D. Smith* 6934; *M. Valerio* 19, 891; *Werckle.*

PANAMA: *Bailey* 401, 476; *Dodge* 3453; *Kenoyer* 23; *Killip* 2819; *Maxon* 4782, 6723; *Seibert* 641; *Skutch* 2; *Stork* 105.

COLOMBIA: *H. H. Smith* 1055; *Killip & Smith* 14924; *Haught* 1596; *Holton* 30; *Pennell & Rusby* 51; *Schott.*

VENEZUELA: *Rusby & Squires* 378; *Pittier* 10879.

BRITISH GUIANA: *Gleason* 471, 786; *De La Cruz* 3449; *Graham* 379; *Jenman.*

FRENCH GUIANA: *Sagot* 720.

BRAZIL: *Burchell* 1529, 9882; *Dusén* 11469, 14733; *Haerchen* (*Rosen-*

stock 72); *Lützelburg* 12918; *Martius* 357; *Pickel* 2251; *Regnell* III. 1444 in part; *Schmalz* 57; *L. B. Smith* 2008; *Wacket* 96.

PARAGUAY: *Balansa* 2830; *Fiebrig* 999; *Hassler* 1539, 4835, 5476; *Jorgensen* 4607.

ARGENTINA: Orán, El Cedral, Prov. Salta, *Rodriguez* 1035. Alrededores de Posadas, Misiones, *Nuñez* 234.

ECUADOR: Balao, *Eggers* 14396.

PERU: *Killip & Smith* 27036; *Klug* 431; *L. Williams* 4236.

BOLIVIA: *Bang* 554 in part; *Steinbach* 7500.

6. **Dryopteris consobrina** Maxon & Morton, sp. nov.

Rhizoma deest. Folia suberecta, usque ad 2.15 m. longa, stipitibus validis (maximis 115 cm. longis, basi 1 cm. diam.), e basi brunnea dilute brunnescentibus, crasse angulato-sulcatis, primum tenuiter et minute puberulis; lamina 1-pinnata, late oblonga, usque ad 1 m. longa et 70 cm. lata, rhachi stipiti simili; pinnae 9–11-jugae et terminalis conformis, subpatentes (maximae 25–30 cm. longae et 3.5–5 cm. latae), anguste lineari-oblongae, apice acuminato-caudatae, basi modice rotundatae vel interdum subabrupte et late cuneatae, subaequales, pleraeque sessiles, solum subapicales plurimae postice semiadnatae, omnes margine callosa argute dentato-serratae, serraturis imprimis pinnae apicem versus uncinatis, parenchyma glabra; venae laterales infra acuminem 60–65-jugae, plerumque 6–8 spatio 3 cm. (raro usque ad 13), sub angulo 70° egredientes, utrinque prominulae, leviter falcatae, subtus pilis obliquis brevibus perpaucis praeditae; areolae 12–22-seriatae, breves, steriles venulis inaequalibus obliquis formatae, fertiles venulis sub angulo latissimo eductis et arcuatim conjunctis formatae; sori anguste oblongi, propinqui sed vetuste etiam non confluentes; sporangia glabra.

Type in the U. S. National Herbarium, nos. 1,464,533 and 1,464,534 (a sterile frond) and no. 1,692,123 (basal portion of a fertile frond), collected in a wooded valley near La Merced, Dept. Junín, Peru, altitude about 700 meters, June 4, 1929, by E. P. Killip and A. C. Smith (no. 24087). Duplicate in herb. New York Botanical Garden. Other specimens examined:

PERU: Type locality, *Killip & Smith* 23514 (US, Y). Río Apurimac Valley, near Kimpitiriki, alt. 400 meters, edge of dense forest along beach, *Killip & Smith* 22945 (US, Y).

In its uncinate-serrate margins the present species resembles *D. serrata*, from which, highly variable though the latter is, it is readily distinguished as above indicated. The Apurimac Valley specimen (*Killip & Smith* 22945) clearly belongs to *D. consobrina*, but it is under-sized and its dimensions are not included in the description.

7. **Dryopteris Salzmanni** (Fée) Maxon & Morton, comb. nov.

Meniscium Salzmanni Fée, Gen. Fil. 223. 1853.
Meniscium elongatum Fée, Crypt. Vasc. Brés. **1**: 83. *pl. 25, fig. 1.* 1869.
?*Meniscium sessilifolium* Pohl; Fée, op. cit. 84.

This species was described by Fée from Bahia material collected by Salzmann. It has very generally been disregarded, most specimens having been referred to *D. reticulata*, which in every way is a much larger plant. The pinnae of *D. Salzmanni* are more rigid and ascending and have fewer, more acute areoles. The relationship is probably somewhat closer to *D. serrata* than to *D. reticulata*.

Specimens examined are as follows:

BRAZIL: State of Bahia: Bahia, *Salzmann*, type coll. (B, C, Y); *Glocker* 189 (K). State of Rio de Janeiro: Without locality, *Glaziou* 1169, type coll. of *M. elongatum* (C); Serra dos Orgaos, near Pereira, *Lützelburg* 6024 (C, US); Corcovado, *Voy. Herald* 167 (K); Organ Mts., alt. 1000–1500 meters, *Rose & Russell* 20803 (US, Y); Mt. Itatiaya, alt. 800 meters, *L. B. Smith* 1648 (C, US). State of Minas Geraes: Viçosa, alt. 680 meters, *Mexia* 4683 (US), 4857a (US); Lagoa Santa, *Warming* 793 (C, 4 sheets). State of Maranhao: Victoria Alto Parnahyba, *Snethlage* 724 (F). State of São Paulo: Campinas, *Ulbricht* (*Rosenstock* 215) (US). Without locality, *Glaziou* 15744 (C).

COLOMBIA: Without locality, *Funck & Schlim* in 1862 (Y).

PERU: Pampayaco, alt. 1050 meters, *Macbride* 5046 (US). Zepelacio, near Moyobamba, alt. 1100–1200 meters, *Klug* 3354 in greater part (K, US, Y). Valley of Pillahuata, Province of Paucartambo, *Herrera* 1622 (US).

8. DRYOPTERIS TURRIALBAE Rosenst. Repert. Sp. Nov. Fedde **22**: 10. 1925.

A Costa Rican form, described from specimens collected on the lower Atlantic slopes near Turrialba, altitude 650 meters, Aug. 1909, by Alfredo and Curt Brade (no. 357). It is by far the most weakly characterized of any of the species here recognized and may prove no more than a geographic variety of the West Indian *D. reticulata*, from which it differs mainly in the shape of the pinnae. The following collections have been studied:

COSTA RICA: Turrialba, alt. 650 meters. *A. & C. Brade* 357, type coll. (Y); Banks of Río Colorado, near Turrialba, alt. 600 meters, *Tonduz* 8287 (US). Tuis, Prov. Cartago, alt. 650 meters, *Tonduz* 11321 (K, US); same, distributed as *J. D. Smith* 7325 (K, US).

9. DRYOPTERIS RETICULATA (L.) Urban, Symb. Antill. **4**: 22. 1903.

Polypodium reticulatum L. Syst. Nat. ed. 10, **2**: 1325. 1759.
Asplenium sorbifolium Jacq. Coll. Bot. **2**: 106. *pl. 3, fig. 2.* 1788.
Meniscium sorbifolium Dessrous. in Lam. Encyl. **4**: 93. 1797.
Meniscium Schreberi Rich. Act. Soc. Hist. Nat. (Paris) **1**: 114. 1792 (nomen nudum).
Meniscium reticulatum Sw. Journ. Bot. Schrad. **1801**[2]: 274. 1803.
Diplazium undulosum Sw. Syn. Fil. 92, 284. 1806, in part (as to Plum. Trait. Foug. *pl. 107*).
Meniscium acrostichoides Desv. Mém. Soc. Linn. Paris **6**: 223. 1827.
Phegopteris reticulata Mett. Fil. Lechl. **2**: 24. 1859.
Phegopteris sorbifolia Mett. op. cit. 23.
Nephrodium reticulatum Keys. Pol. Cyath. Herb. Bung. 49. 1873.
Nephrodium sorbifolium Hieron. Bot. Jahrb. Engler **34**: 449. 1904, as to name; not Presl (1825).
Dryopteris reticulata var. *sorbifolia* Suesseng. Rev. Südamer. Bot. **1**: 82. 1934.

As previously stated, the sole basis of Linnaeus' description of *Polypodium reticulatum* is the Plumier illustration (plate 9, republished as plate 110). This was cited also under *Asplenium sorbifolium* by Jacquin, whose diagnosis leaves no doubt that he was redescribing the Linnaean species under another name. This identity was recognized by early authors; but later writers, beginning perhaps with Schott, wrongly associated the name *sorbifolium* with a South American species (*D. Hostmanni*) that is not very closely related to *D. reticulata* and is not known to occur in the West Indies. Still later the name came to be applied generally but very mistakenly to the species which we here call *D. permollis*.

Due allowance being made for age and varying habitat, *D. reticulata* is a very constant species. The following specimens, mainly in the National Herbarium, have been examined:

FLORIDA: Alapattah, on cypress knees, *Eaton* 779 (US, Y).

JAMAICA: *Alexander; Clute* 149; *Fredholm* 3209; *Maxon* 1004, 1710, 2282, 2371, 2552, 8948, 9358, 10323; *Maxon & Killip* 24, 502, 1542; *Underwood* 2986; *Watt* 162.

CUBA: *Britton et al.* 5142, 7537, 14742; *Clément* 1313; *Eggers* 5019; *Hioram* 1396, 6457; *Linden* 2116; *Maxon* 4208, 4254; *Palmer & Riley* 82, 917, 1026, 1048; *Pollard et al.* 48; *Shafer* 4366, 8568, 8955, 10651, 10688, 13689; *Wright* 782, 1084.

HISPANIOLA: *Abbott* 37, 74, 77, 610, 746, 1442, 2166; *Eggers* 2315; *Ekman* 3823, 11549; *Fuertes* 1682; *Leonard* 9188; *Miller* 1162; *Nash & Taylor* 1053; *Valeur* 336, 827.

PUERTO RICO: *Britton et al.* 8398; *Eggers* 724; *Fisher* 69 in part; *Goll* 682; *Heller* 1034; *Hioram* 87; *Shafer* 3232; *Sintenis* 132, 2338, 6584; *Stevenson* 6120; *Underwood & Griggs* 267, 530.

LEEWARD ISLANDS: St. Kitts, *Box* 263; *Britton & Cowell* 181. Guadeloupe, *Stehlé* 511, 654, 1096, 1876. Dominica, *Bailey* 763.

WINDWARD ISLANDS; Montserrat, *Miller* 1924; *Ryan* 169; *Shafer* 202, 736, 738; *Turner*. Martinique, *Duss* 1611; *Hahn* 29; *Isert* in 1787; *Miller* in 1924; *Thiébaut* in 1876. St. Vincent, *Guilding*. Grenada, *Eggers* 6057; *Murray & Elliott* 11; *Sherring* 35. St. Lucia, *Box* 452, 491.

ISLAND OF MARGARITA (Venezuela); Juan Griego trail, alt. 450 meters, *Johnston* 166 (6 sheets). El Valle, *Miller & Johnston* 156 (3 sheets).

The altitudinal range is from sea-level to a maximum of 900 meters.

10. DRYOPTERIS ENSIFORMIS C. Chr. Dansk. Vid. Selsk. Skrift. VII. Naturv. Afd. **10**[2]: 269. *fig. 46*. 1913.

Founded on a Costa Rican plant (*Tonduz* 12533), and now to be reported also from Peru and Venezuela. We regard this as an excellent species, although the points stressed by Christensen do not seem of special significance. These were: (1) The presence of an aerophore, (2) the cartilaginous margins, and (3) the long excurrent venules, which often are extended to the next cross-veins. The aerophore was not seen but was postulated from the presence of a dark spot upon the rachis at the base of the pinnae. This was considered to be the scar of a fallen aerophore. But these spots are to be observed in most if not all species of *Meniscium*, and although we have examined a great amount of material we have found no evidence of aerophores. On the contrary these dark spots themselves, which are verruculose, presumably function as ventilation areas. Cartilaginous margins are common to other large coarse species of *Meniscium*. As to venation, the fact that the excurrent venules are sometimes united to form a more or less continuous intermediate vein parallel to the true lateral veins is not a distinctive character, this condition being quite as common in *D. Jurgensenii*. In the type collection of *D. ensiformis* the sori are commonly though not always paired, but this is not true in other specimens of this species. As mentioned under *D. lingulata*, paired sori in this group may be regarded as an abnormal atavistic condition.

Dryopteris ensiformis is most closely related to *D. Jurgensenii*, from which it differs in having the pinnae sessile and subcordate at base (in decided contrast to the cuneate-based, long-stalked lower pinnae of the latter), and in its wholly glabrous blades, at least a few hairs being found along the costae and veins of *D. Jurgensenii*.

The following specimens have been examined:

COSTA RICA: Lisière des Paturâges à La Palma, alt. 1459 meters, *Tonduz* 12533, type coll. (C, US); *C. Brade* 104 (US). Without locality, *Werckle* (US).

PERU: Schunke Hacienda, above San Ramón, Dept. Junín, alt. 1400–1700 meters, in forest, *Killip & Smith* 24651 (US, Y).

VENEZUELA: Near Tovar, *Fendler* 232 in part (B).

11. **Dryopteris Jurgensenii** (Fée) Maxon & Morton, comb. nov.

Meniscium falcatum Liebm. Dansk. Vid. Selsk. Skrift. V. **1**: 183. 1849.
Meniscium Jurgensenii Fée, Gen. Fil. 223. 1852 (as *M. Jungersenii*).
Phegopteris falcata Mett. Fil. Lechl. **2**: 23. 1859.
Dryopteris pachysora Hieron. Hedwigia **46**: 351. *pl. 7, fig. 9*. 1907.
Dryopteris sorbifolia var. *confertivenosa* Hieron. op. cit. 350.
Dryopteris sorbifolia var. *punctivenulosa* Hieron. loc. cit.
Dryopteris falcata C. Chr. Dansk. Vid. Selsk. Skrift. VII. Naturv. Afd. **10**^{2}: 270. 1913, not Kuntze (1891).

The present species, latterly recognized as valid, was first described as *Meniscium falcatum* Liebm., but unfortunately this epithet is invalid under *Dryopteris*. *Meniscium Jurgensenii* Fée, founded on *Jurgensen* 917 from Mexico, is obviously the same.

Dryopteris Jurgensenii is now found to be common, ranging from southern Mexico to Bolivia. In spite of very considerable extremes in size, the specimens here cited are relatively constant in venation. The venules are straight or nearly so and meet at a broad angle, and the false intermediate lateral veins sometimes formed by the intermittently joined excurrent venules imperfectly divide the areoles into trapeziform halves. This is markedly different from the condition seen in *D. reticulata*, *D. Salzmanni*, and most other species, in which the venules are obviously curved (subsigmoid), at least in the sterile pinnae.

The following specimens have been examined:

MEXICO: Near Lacoba, Distr. Chinantla, Puebla, alt. 600–750 meters, *Liebmann* 679, 680, 2756, type of *M. falcatum* (C, K, US).

BRITISH HONDURAS: Big Creek, near sea level, along river banks, *Schipp* 97 (C, F, K, US).

GUATEMALA: Near Finca Sepacuité, *Cook & Griggs* 667 (US). Livingston, *Deam* 453 (Y). Sierra del Mico, alt. 600 meters, *Kellerman* 7212 (F). Puerto Barrios, at sea level, *Standley* 25003 (US), 25017 (US). Cubilquitz, Alta Verapaz, alt. 350 meters, *Tuerckheim* (*J. D. Smith* 8039) (US).

NICARAGUA: Castillo El Viejo, along Río la Juana, *Shimek* (F). San Juan del Norte, *C. L. Smith* 2030 (US, Y).

COSTA RICA: Llanuras de San Carlos, alt. 200 meters, *Brade* 485 (Y).

Pejivalle, *Lankester* 819 (US). Buenos Aires, in forest, *Pittier* 4839 (US). El General, Prov. San José, alt. 950 meters, *Skutch* 2181 (US).

PANAMA: Chagres, *Fendler* 404 (K, US). Near Laguna de Chiriquí, *Hart* 16 (US). Hilly forest near Las Cascadas, Canal Zone, alt. 50–225 meters, *Maxon* 4895 (US). Along Río Culebra, above Santa Isabel, Prov. Colón, near sea level, *Pittier* 4153 (US). Near San Felix, eastern Chiriquí, *Pittier* 5209 (US).

COLOMBIA: Bay of Utria, *Seemann* (K). Monte la Tortuga, *García* 4600 (US). Puerto Berrio, Dept. Santander, alt. 100–700 meters, *Haught* 1842 (US). Chocó, *Schott* 24 & s. n. (F, US, Y); *Seemann* 972 (K). Between Honda and Bogotá, *Stübel* 392, type of *D. sorbifolia* var. *confertivenosa* (B). Near Muzo, Dept. Cundinamarca, *Stübel* 544, type of *D. sorbifolia* var. *punctivenulosa* (B). Without locality, *Lehmann* 5034 (K, US); *Mutis* 3299 (US).

PERU: East of Quimirí Bridge, near La Merced, Dept. Junín, alt. 800–1300 meters, in forest, *Killip & Smith* 23890 (US, Y). Pichis Trail, Yapas, Dept. Junín, alt. 1350–1600 meters, in forest, *Killip & Smith* 25570 (US, Y).

BOLIVIA: Hacienda Simaco, on road to Tipuani, alt. 1400 meters, *Buchtien* 5158 (C, US, Y). Apolo, alt. 150 meters, *R. S. Williams* 1254 (Y).

12. DRYOPTERIS ANGUSTIFOLIA (Willd.) Urban, Symb. Antill. **4**: 21. 1903.
Meniscium angustifolium Willd. Sp. Pl. **5**: 133. 1810.
Phegopteris angustifolia Mett. Fil. Lechl. **2**: 22. 1859.

This species, here taken up in the usual sense, was founded on a Caracas specimen collected by Bredemeyer. It had been described and illustrated originally by Sloane[16] as "*Filix major in pinnas tantum divisa oblongas angustatas, non crenatas.*" Both specimens have been examined by the senior author, at Berlin and the British Museum (Natural History).

Dryopteris angustifolia is common in the Greater Antilles, ascending from sea level to about 700 meters, but is unknown from the Lesser Antilles. On the continent it ranges from Costa Rica to Paraguay, reaching an altitude of 1100 to 1400 meters in Colombia, but oddly enough is apparently wanting in Brazil. In all probability the continental range could be considerably amplified by examining material in other herbaria. Most of the following specimens are in the U. S. National Herbarium.

JAMAICA: *Clute* 270; *Crawford* 805; *Hart* 346; *Maxon* 799, 1824, 8851; *Maxon & Killip* 144.

CUBA: *Clément* 1785; *Hioram* 1479; *Maxon* 4319; *Wright* 781.

HISPANIOLA: *Abbott* 2017, 2579; *Ekman* 5638, 12298; *Leonard* 8730, 12296; *Miller* 1133; *Nash & Taylor* 1221; *Valeur* 319.

[16] Nat. Hist. Jamaica **1**: 84. *pl. 40.* 1707.

PUERTO RICO: *Britton et al.* 3935, 8429, 8580; *Dale* 10; *Eggers* 1336; *Heller* 1398; *Hess* 339; *Hioram* 264; *Shafer* 3144; *Sintenis* 4547, 4657; *Wilson* 53, 348.

MEXICO: Lacoba, Chinantla, Puebla, *Liebmann*.

GUATEMALA: Near Mazatenango, *Bernoulli* 446.

COSTA RICA: La Fortuna, *Biolley* in 1906. Pasoagres, near Alajuela, *Lankester* 605.

PANAMA: Chagres, *Fendler* 397. Juan Diaz River, *Killip* 2559. Río Tapia, Prov. Panamá, *Standley* 28122. Obispo, Canal Zone, *Standley* 31692.

COLOMBIA: Santa Marta, *Mrs. Dora Bennett* 29; *Niemeyer* 36; *H. H. Smith* 1053. East of Zarzal, Dept. El Valle, *Pennell, Killip & Hazen* 8538, 8583. Without locality, *Mutis* 3284. Dibulla, Dept. Magdalena, *Seifriz* 279 in part.

PERU: Río Paucartambo Valley, near Perene Bridge, Dept. Junín, *Killip & Smith* 25260. Chazuta, Río Huallaga, Dept. San Martín, *Klug* 4035. San Buenaventura, *Cárdenas* 1899.

BOLIVIA: Mapiri, alt. 650 meters, *Tate* 413 (Y).

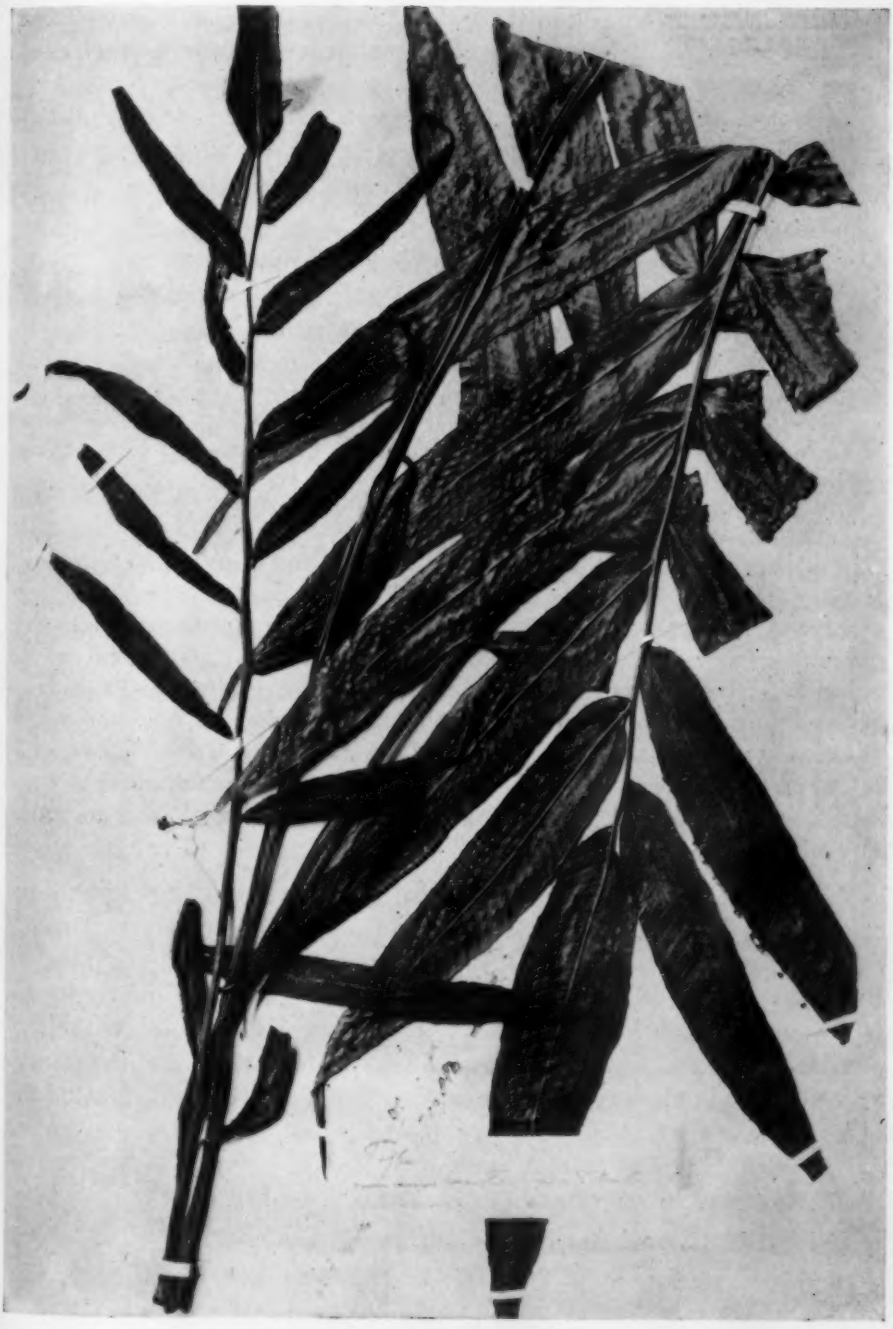
PARAGUAY: Sierra de Amambay, *Hassler* 10508 (K).

13. **Dryopteris nesiotica** Maxon & Morton, sp. nov. PLATE 12

Rhizoma deest. Folia rigide suberecta, usque ad 95 cm. longa, subbiformia, stipitibus validis, pallide brunneis, profunde et anguste sulcatis, cum rhachi minute puberulis, eis foliorum sterilium quam laminis multo brevioribus, eis fertilium laminas subaequantibus; lamina 1-pinnata; pinnae 9-11-jugae et terminalis conformis, adscendentes, integrae, inferiores plurimae subopppositae, ceterae alternae. Laminae steriles ambitu late oblongae, 40–55 cm. longae, ca. 30 cm. latae; pinnae subaequales, 16–22 cm. longae, 2.5–3 cm. latae, late lineares, parte apicali longe attenuatae, basi obtusae vel rotundatae, vel superiores antice obliquae, hae postice plus minusve adnatae, ceterae sessiles (infimae brevissime petiolulatae exceptae); venae laterales infra acuminem ca. 40-jugae, spatio 3 cm. ca. 8, sub angulo 60°–70° egredientes, leviter falcatae, fere glabrae, utrinque prominulae; venulae leviter curvatae, sub angulo 45° eductae, inaequales, angulo subrecto conjunctae, utrinque prominulae; areolae 9–11-seriatae, breves, venulis excurrentibus brevibus. Laminae fertiles oblongae; pinnae remotae, lineares, 9–13 cm. longae, attenuatae, basi inaequaliter subcuneatae, sessiles (superiores semiadnatae exceptae); sporangia glabra, areolarum arcum totum insidentia, creberrima et numerossisima, pinnae pagina inferiori (costa excepta) suffusa.

Explanation of Plate 12

Plate 12. *Dryopteris nesiotica* Maxon & Morton, sp. nov. The type specimen; Trinidad, *Jenman*. About half natural size.



MAXON & MORTON: DRYOPTERIS

Type in the herbarium of the New York Botanical Garden, collected in Trinidad by G. S. Jenman, together with a second specimen which is evidently of the same collection.

The present species is allied to *D. angustifolia*, but is at once distinguished by its broad sterile pinnae, which except for the basal pair are neither stalked nor cuneate, and by its distant lateral veins.

14. **Dryopteris dispar** Maxon & Morton, nom. nov.

Meniscium affine Presl ex Ettingsh. Denkschr. Akad. Wiss. Math. Naturw. (Wien) **23:** 94. *pl. 13, fig. 3.* 1864; Farnkr. Jetztw. 170. *fig. 73; pl. 135, fig. 16.* 1865. Not *Dryopteris affinis* Newm. 1854.

Since its original publication this species, from "Brazil," has remained unknown, having been described inadequately on characters of venation only and without citation of specimens. We give here an amplified description:

Stipe about equaling the blade, slender (2 mm. in diameter), stramineous, lustrous, glabrous; blades imparipinnate, oblong in outline, 50 cm. long, 20 cm. broad, the rachis stramineous, lustrous, glabrous; pinnae 9-jugate, subopposite, membraneous, linear-falcate, up to 14.5 cm. long and 1.7 cm. wide, acuminate-attenuate in apical fourth, subsessile, at base obtuse and rounded-auriculate on both sides; margins subentire; leaf surface, costae, and veins glabrous except for scattered whitish stipitate glands, the lateral veins about 11 pairs in the space of 3 cm.; venules almost straight, meeting each other at an obtuse angle, the areoles 4–6-seriate; sori not confluent; sporangium stalk setose.

The above description is drawn from a specimen in the Kew Herbarium collected on bank of the Río Mauhy, in the state of Amazonas, Brazil, by J. W. H. Traill (no. 1402). It does not agree exactly with the plate of Ettingshausen, for in that the areoles are only 3- or 4-seriate and the bases of the pinnae not auriculate. In the present specimen the areoles are mostly 5-seriate. However, since no other species has so few areoles and the plants otherwise are in close general agreement, we believe the identification to be correct.

15. DRYOPTERIS SIMPLICIFRONS C. Chr. Ind. Fil. 486. 1906.

Meniscium giganteum Mett. Fil. Lechl. **1:** 19. 1856.
Phegopteris gigantea Mett. Fil. Lechl. **2:** 22. 1859.
Nephrodium giganteum Diels in Engl. & Prantl, Pflanzenfam. 1^4: 177. 1899; not Baker (1867), Baker (1874), nor Cesati (1877).
Dryopteris gigantea C. Chr. Ind. Fil. 267. 1905; not Kuntze (1891).

This well-known species, founded on material from St. Gavan, Peru (*Lechler* 2292), is at once recognized by its large simple fronds. Christensen intimates that pinnately divided forms are found, but we have seen no specimens so named nor any that can be referred to this species. Such material would very likely be referable to *D. Andreana* or *D. membranacea*. The closer relationship of *D. simplicifrons* is undoubtedly with the latter, with which it agrees in having appendages borne on the stalk of the sporangium. In *D. membranacea* these are in the form of sharply pointed hyaline setae, whereas those of *D. simplicifrons* are stalked capitate glands. The stalk of the gland is often rather long, and the gland itself is large, spherical and of a dark red color. At first these glands are very conspicuous among the sporangia, but they appear to be readily deciduous and are not to be seen on older specimens.

Unfortunately the specific name *gigantea*, being preoccupied for an Old World *Tectaria*, can not be retained for the present species, the "new combination" *Dryopteris gigantea* (Mett.) C. Chr. having been published in spite of *Dryopteris gigantea* Kuntze (1891), which is listed on the same page. In a succeeding fascicle of the Index Filicum (p. 486), which appeared the next year (1906), the new name *Dryopteris simplicifrons* is validly published by Christensen as the equivalent of *Phegopteris gigantea* Mett. and this, though it has subsequently been ignored by Christensen himself and by other writers, must now be taken up.

Dryopteris simplicifrons inhabits dense humid forests, from lower altitudes to about 1500 meters. It ranges from Costa Rica to Peru, but is yet to be found in Panama. The following specimens have been studied:

Costa Rica: Forest above Tsaki, Talamanca, alt. 500 meters, *Tonduz* 9448. Peralta, alt. 600–700 meters, *Lankester*. Without locality, *Werckle*.

Colombia: Along Río Guatapé, Dept. Antioquia, alt. 1040 meters, *Kalbreyer* 1453 (K). "Ciñegetas," Dept. Antioquia, alt. 1200–1500 meters, *Kalbreyer* 1865 (K). Along Río Timbiquí, near Coteje, Dept. Cauca, alt. 100–500 meters, *Lehmann* 8946 (K, US); also *Lehmann* as B. T. 444 (K, US).

Ecuador: Forests at 300–1200 meters, Aug. 1875, *Sodiro* 54 (K, 3 sheets).

Peru: St. Gavan, in shady wet forests, *Lechler* 2292, type coll. (K). Pichis Trail, San Nicolas, Dept. Junín, alt. 1100 meters, *Killip & Smith* 26018 (US).

16. Dryopteris membranacea (Mett.) C. Chr. Ind. Fil. Suppl. 35. 1913. Plate 13

Phegopteris membranacea Mett. Fil. Lechl. **2**: 22. 1859.

Nephrodium Lechleri Hieron. Bot. Jahrb. Engler **34**: 448. 1904.
Dryopteris Lechleri C. Chr. Ind. Fil. 274. 1905.

Phegopteris membranacea was described by Mettenius with citation of two Peruvian specimens collected by Lechler, viz. (1) no. 1785, from Azangaro, which he had previously listed[17] as *M. reticulatum*, and (2) an unnumbered specimen from St. Gavan. His description is ample and clearly applies to the species subsequently described as *Nephrodium Lechleri* by Hieronymus, who based his description upon *Lechler* 1785, from Azangaro, and *Lechler* 2321, from St. Gavan, the latter being presumably the second specimen cited by Mettenius as *P. membranacea*. In so doing Hieronymus appears to have regarded the Berlin material as an aggregate and to have fallen into the error of selecting typical *membranacea* for description as a new species, wrongly applying the name *membranacea* to another Lechler specimen from St. Gavan, viz. no. 2493. A photograph of no. 2493 has kindly been forwarded from Berlin. It shows a large *sterile* blade, with *nine* pairs of pinnae below the greatly enlarged *pinnatifid* apex. The specimen thus disagrees widely with Mettenius' description, does not bear an annotation by him, and certainly was not included in his *original* concept of *P. membranacea*. If not actually teratological, it is at least highly atypical for any known member of this genus and can not at present be placed specifically.

Thus, *Nephrodium Lechleri* and *Dryopteris Lechleri* are exactly the equivalent of *D. membranacea* and, having been based on the same specimens as that, are illegitimate. Technically, according to Article 60 of the International Rules of Nomenclature, they may be disregarded.

We have seen only the following specimens, though Hieronymus lists this species (as *D. Lechleri*) from Ecuador on the basis of *Stübel* 1002.

COLOMBIA: Between Pueblo Viejo and San Miguel, Dept. Magdalena, alt. 900–1700 meters, *Seifriz* 556 (US).

PERU: In rupibus umbrosis prope Azangaro, *Lechler* 1785, type coll. (K, 2 sheets). Mishuyacu, near Iquitos, alt. 100 meters, in forest, *Klug* 200 (US); *Klug* 1533 (US, Y). Chazuta, Río Huallaga, Dept. San Martín, alt. 260 meters, in forest, *Klug* 3970 (US, Y). Mt. Campana, near Tarapoto, *Spruce* 4645 (K, US).

Reference of the last collection to *D. membranacea* is somewhat doubtful, on account of its conspicuously strigose costae and veins. The speci-

[17] Fil. Lechl. 1: 19. 1856.

Explanation of Plate 13

Plate 13. *Dryopteris membranacea* (Mett.) C. Chr. Isotype specimen, at Kew; Peru, *Lechler* 1785. About half natural size.

MAXON & MORTON: DRYOPTERIS

mens are very immature, however, and are only slightly more hairy than one of the two specimens of *Lechler* 1785, this also being very young, with most of the sporangia undeveloped.

17. **Dryopteris Standleyi** Maxon & Morton, sp. nov.

Rhizoma deest. Folia conformia, rigide suberecta, usque ad 1.9 m. longa, stipitibus validis, quam laminis multo longioribus, e basi fusca pallide brunnescentibus vel ochraceo-stramineis, obtuse angulatis, minute et laxe puberulis; lamina 1-pinnata. Laminae steriles late oblongae, usque ad 50 cm. longae et 40 cm. latae, apice acutiusculae vel abrupte acutae; pinnae 12–17-jugae et terminalis conformis, subpatentes, subimbricatae, margine subintegrae vel leviter repandae, pleraeque superiores sensim minores, ceterae subaequales, ligulatae, 12–22 cm. longae, 2.5–4 cm. latae, apice acutae vel attenuatae, basi late rotundatae vel pleraeque subcordatae, omnes sessiles; venae laterales spatio 3 cm. 9–13, sub angulo 60° egredientes, utrinque prominulae, subtus cum venulis pilis curvatis brevibus paucis praeditae; venulae sub angulo 35°–40° eductae, longae, acutissime conjunctae; areolae 9–14-seriatae, breves, profunde antice curvatae, venulis excurrentibus plerumque longis sed liberis; parenchyma chartacea, pilis rigidis parvis hinc inde praedita, mox glabrescens. Laminae fertiles anguste oblongae, usque ad 70 cm. longae et 40 cm. latae, apice abrupte acutae; pinnae obliquae, ca. 17-jugae et terminalis, sterilibus similes sed plerumque angustiores (maximae 22 cm. longae et 2.5–4 cm. latae), apice attenuatae, basi non reductae, sessiles, margine irregulariter sinuatae vel crenatae, superiores paulum minores; venae laterales spatio 3 cm. 13–15, sub angulo 75° egredientes, prominulae, subtus cum venulis pilos breves paucos ferentes; venulae sub angulo ca. 45° eductae, rectae, angulo obtuso conjunctae, venulis excurrentibus liberis hydathoidis linearibus terminatis; areolae 11–14-seriatae, dimidiis trapeziformibus; sori magni, late oblongi, crebri, aetate confluentes, sporangiorum pedicellis setis rigidis solitariis vel binis supra instructis.

Type in the U. S. National Herbarium, nos. 1,150,894–6, representing two complete fronds (fertile and sterile), collected on a brushy bank near Quiriguá, Dept. Izabal, Guatemala, altitude 75 to 225 meters, May 15–31, 1922, by Paul C. Standley (no. 24126). Other specimens examined are as follows:

MEXICO: Cerro de Tonala, in a forest ravine, *C. & E. Seler* 2013 (US).

COLOMBIA: Near Onaca, Santa Marta, alt. 750 meters, boggy situations in "open land" ravines, *H. H. Smith* 2458, 7 specimens (F, US, Y).

PERU: Zepelacio, near Moyobamba, Dept. San Martín, alt. 1100 to 1200 meters, *Klug* 3354 in part (U. S.).

BOLIVIA: San Carlos, Mapiri region, alt. 850 meters, *Buchtien* 228 (G).

Closely related to the present species is a form from Taboga Island, Panama (*Killip* 2642; *Standley* 28025), which very likely is specifically

distinct. It is similar in venation but is definitely pilosulous beneath, in strong contrast to the essentially glabrous leaf tissue of *D. Standleyi*. The Killip specimen is remarkable also for its widely distant pinnae.

18. **Dryopteris Hostmanni** (Klotzsch) Maxon & Morton, comb. nov.

PLATE 14

?*Meniscium arborescens* Humb. & Bonpl.; Willd. Sp. Pl. **5**: 133. 1810. Not *Dryopteris arborescens* Kuntze (1891).

Polypodium Hostmanni Klotzsch, Linnaea **20**: 397. 1847.

Meniscium Kapplerianum Fée, Gen. Fil. 224. 1852.

?*Phegopteris arborescens* Mett. Fil. Lechl. **2**: 24. 1859.

?*Dryopteris reticulata* var. *arborescens* Brause, Verh. Bot. Ver. Brand. **51**: 2. 1910.

Polypodium Hostmanni Klotzsch was described from Surinam upon material collected by Hostmann and Kappler (no. 828), and the same number served also as the sole basis of *Meniscium Kapplerianum* Fée. Whether *Meniscium arborescens* Humb. & Bonpl. is the same appears to be highly problematical. Not only Humboldt and Bonpland but Mettenius, who saw the plant in cultivation, describe it as arborescent. In the specimens of *D. Hostmanni* that we have seen there is no evidence of such a development, otherwise unknown in *Meniscium;* yet Hieronymus also regarded *arborescens* and *Hostmanni* as synonymous. In any case, the name *arborescens* is not available, being preoccupied by *Dryopteris arborescens* (Baker) Kuntze, 1891, applied to a Samoan plant.

The specimens cited below are of uniform facies, one of the largest being a frond collected by Jenman, in which the pinnae are 2 to 2.5 cm. broad. Sporangium setae are conspicuous in all.

PANAMA: Río Cañazas, Prov. Veraguas, *Allen* 164 (US).

DUTCH GUIANA: In sylvis humidis, *Hostmann & Kappler* 828, type coll. (B, K, Y). Without locality, *Wullschlaegel* (F, Y).

BRITISH GUIANA: Pirana, *Appun* 1469 (K). Rockstone, in dense upland forest, *Gleason* 609 (US, Y). Demerara River, *Jenman* (Y, 2 sheets); *Jenman* 3845 (K).

19. **Dryopteris Desvauxii** Maxon & Morton, nom. nov.

Meniscium longifolium Desv. Mém. Soc. Linn. Paris **6**: 223. 1827.

Meniscium longifolium Fée, Crypt. Vasc. Brés. **1**: 84. *pl. 25, fig. 2*. 1869.

Nephrodium longifolium Hieron. Bot. Jahrb. Engler **34**: 449. 1904.

Dryopteris longifolia (Fée) Hieron. Hedwigia **46**: 351. 1907.

Dryopteris reticulata var. *longifolia* (Desv.) Rosenst. in Buchtien, Contr. Fl. Bol. **1**: 44. 1910.

The present species offers an unusual problem in nomenclature, recently discussed by Mr. C. A. Weatherby[18] in his paper on the ferns proposed by Desvaux as new. Both Desvaux and Fée described independently this fern under the same name, *Meniscium longifolium*, but upon different material. Fée's name is a later homonym, yet Hieronymus in transferring the species to *Dryopteris* used it, rather than the *longifolium* of Desvaux. Since Fée's epithet is illegitimate, the new combination made by Hieronymus under *Dryopteris* is equally so; nevertheless it makes impossible the transfer now of the epithet given by Desvaux. A new name must therefore be given, as above.

As here considered *D. Desvauxii* shows great variability. It is close to *D. permollis*, though typical specimens of the two are quite different. Usually it is a much larger plant, with longer-stalked pinnae, and a shorter less dense pubescence. Especially noteworthy is the presence of stalked capitate glands, which normally replace the hairs of the leaf surface to a considerable extent. In some specimens all the hairs are replaced by glands, in which case the plants appear so different that their formal recognition seems desirable. The following specimens of the typical form have been examined:

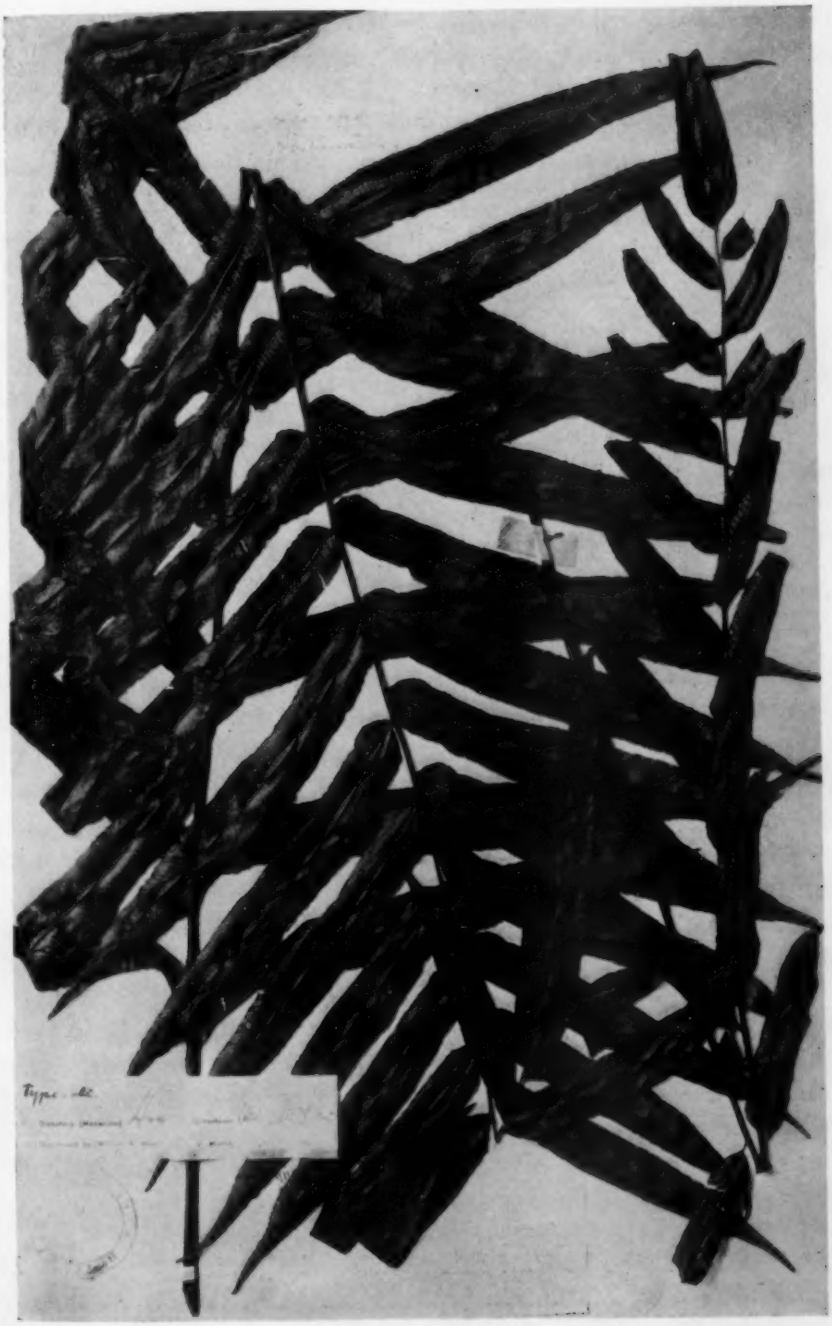
BRAZIL: State of Amazonas: Manaos, *Gleason* 11 (Y); Barra do Rio Negro, *Spruce* 1243 (K); near San Gabriel, along Rio Negro, *Spruce* 2141 (K, US). State of Para: Near Gurupatuba, west of Monte Alegre, *Traill* 1403 (K). State of Ceara: Serra de Araripa, *Gardner* 1904 (K). State of Goyaz: *Glaziou* 22633 (B, K). State of Espirito Santo or Bahia: *Blanchet* 3984 (C, K). State of Minas Geraes, *Regnell* III. 1444 in part (US). Rio de Janeiro: Organ Mts., *Gardner* 103 (K); Valence, *Glaziou* 1747, type coll. of *M. longifolium* Fée (C, K, US); without definite locality, *Glaziou* 2375, paratype coll. of *M. longifolium* Fée (C, K); Petropolis, *Spannagel* 523 (Y). State of Paraná: Jacarehy, *Dusén* 6580 (B, F, US); Serra do Mar, Porto de Cima, *Dusén* 14679 (C, F); Alexandra, *Dusén* 10159 (B, K, US), 15258 (F). State of Santa Catharina: Joinville, etc. *Schmalz*, partly as no. 166 (F, US, Y). Without locality, *Burchell* 2635 (K); *Glaziou* 15743 (C), 15745 (C).

BOLIVIA: San Antonio, near Mapiri, *Buchtien* 1063 (US). Roboré,

[18] Contr. Gray Herb. **114**: 27. 1936. A photograph of Desvaux's type specimen has very kindly been furnished by Mr. Weatherby.

Explanation of Plate 14

Plate 14. *Dryopteris Hostmanni* (Kl.) Maxon & Morton. Isotype specimen, at Kew; Dutch Guiana, *Hostmann & Kappler* 828. About half natural size.



MAXON & MORTON: DRYOPTERIS

Cárdenas 2991 (US). Buena Vista, Dept. Santa Cruz, *Steinbach* 5312 (US). San José, *R. S. Williams* 1245 (US, Y).

19a. **Dryopteris Desvauxii** f. **glandulosa** Maxon & Morton, forma nov.

Lamina pilis destituta, glandulis stipitatis capitatis albidis instructa.

Type in herbarium of the New York Botanical Garden, collected at Morro das Pedras, São Paulo, Brazil, February 1928, by Brade (no. 5753). Other specimens examined are as follows:

BRAZIL: State of Goyaz, *Glaziou* 22632 (F, Y). State of São Paulo: Santos, *Lindberg* 545 (K). State of Paraná: Alexandra, *Dusén* 15258 (US).[19]

BOLIVIA: Mapiri, alt. 480 meters, *R. S. Williams* 1281 (Y).

PERU: Mishuyacu, near Iquitos, Dept. Loreto, alt. 100 meters, *Klug* 509 (US).

20. **Dryopteris permollis** Maxon & Morton, nom. nov.

Phegopteris mollis Mett. Ann. Sci. Nat. V. Bot. **2:** 242. 1864. Not *Dryopteris mollis* (Jacq.) Hieron. 1907.

Nephrodium sorbifolium var. *molle* f. *angustipinnata* Hieron. Bot. Jahrb. Engler **34:** 449. 1904.

Dryopteris sorbifolia var. *mollis* Hieron. Hedwigia **46:** 351. 1907.

This species, as *Phegopteris* (*Meniscium*) *mollis*, was well described by Mettenius upon material from Llano de San Martín, Paraiso, Colombia, alt. 300 meters, collected by Triana. It was reduced to varietal rank by Hieronymus under both *Nephrodium sorbifolium* and *Dryopteris sorbifolia;* but *Meniscium sorbifolium* is exactly synonymous with *D. reticulata*, as discussed under that species, and is not closely related to the present plant. Mettenius' epithet, *mollis*, being preoccupied under *Dryopteris*, a new one is required.

Usually *D. permollis* is readily recognized by its densely soft-pilose under surfaces. Capitate glands are sometimes found among the hairs, but not so commonly as in *D. Desvauxii*. The following specimens have been examined:

COSTA RICA: Buenos Aires, in forest along the Río Ceibo, *Pittier* 4852 (US).

COLOMBIA: Type collection, *Triana* (US). Cali, *André* 429 (F, K, US, Y); *Lehmann* 2937 (K, US). Intendencia del Chocó, along Río Atrato, *Archer* 1808 (US). Río Pauca, *Dryander* 631 (US). Buenaventura, Dept.

[19] A specimen of this number (with identical data) in Field Museum is typical *D. Desvauxii.*

El Valle, *Killip* 11683 (US); *Pennell & Killip* 5295 (US, Y). Mesa de los Santos, Dept. Santander, *Killip & Smith* 15248 (US, Y). Villavicencio, *Pérez* 10 (US). San Carlos, Dept. Antioquia, *Kalbreyer* 1376 (K).

BRITISH GUIANA: Marima, *Appun* 1058 (K).

PERU: Pampayacu, *Kanehira* 129 (US).

BOLIVIA: San Carlos, near Mapiri, *Buchtien* 241 (Y). Antahuacana, *Buchtien* 2210 in part (US). Ticunhuaya, *Tate* 1062 (Y).

The altitudinal range is from sea level to about 1500 meters.

To this species is perhaps to be referred a specimen in the Kew Herbarium collected at Tovar, Venezuela (*Fendler* 232 in part), in which almost all the hairs are suppressed, the veins being conspicuously stipitate-glandular.

21. **Dryopteris chrysodioides** (Fée) Maxon & Morton, comb. nov.

Meniscium chrysodioides Fée, Gen. Fil. 225. 1852.

Fée's description is brief and is followed by the statement, "Habitat in America australi. (Collect. Pamplin., in Herb. cl. Moug., no. 55," neither the country nor collector being indicated.[20] This species has never before been placed very definitely, being listed in the Index Filicum as a synonym of *D. reticulata;* but upon reading Fée's comment, "aspectu *Chrysodii vulgaris,*" it occurred to us independently to associate the name with several British Guiana specimens collected by Jenman, which indeed bear a general resemblance to *Acrostichum aureum* (*Chrysodium vulgare*). They agree well with Fée's description and represent a very well marked species, which presumably attains a greater size than indicated by the description or by Jenman's specimens. These are as follows:

BRITISH GUIANA: Pomeroon River, *Jenman* 2072 (K); *Jenman* s. n. (Y, 2 sheets). Mazaruni River, *Jenman* in 1881 (Y).

Of this species the following is a well-marked variety. It is based on

[20] The following comment on Fée's statement is obligingly furnished by Dr. J. H. Barnhart: "I understand by this that the Mougeot Herbarium contained a collection distinguished as the 'Collectio Pampliniana' and that the specimen in question was either no. 55 of that collection or had had that number assigned to it by Mougeot. The only botanist by the name of Pamplin known to me is William Pamplin, who was an Associate of the Linnaean Society for almost 70 years, and died in 1899 in his ninety-third year. For 23 years (1839–62) he was a book dealer in London, specializing in botanical books, and it would not be at all strange if Mougeot received from him either by gift, exchange, or purchase a collection of botanical specimens. I do not think that Pamplin was ever in any part of America. He traveled all over Great Britain, studying its flora, but I have no evidence that he even crossed the Channel to the Continent." To this Mr. C. A. Weatherby adds that Pamplin's herbarium was purchased by G. C. Druce and is presumably at Oxford University.

Glaziou 22631, which Christensen mentioned as probably representing an undescribed species.

21a. **Dryopteris chrysodioides** var. **goyazensis** Maxon & Morton, var. nov.

Filix maxima, pinnis alternis multijugis ligulatis, sterilibus usque ad 40 cm. longis et 7 cm. latis subintegris acuminatis basi rotundatis breviter petiolulatis subtus praecipue in venis breviter pilosulis, venis primariis 5 vel 6 in spatio 3 cm., venulis subsigmoideis, areolis 16–19-seriatis, pinnis fertilibus minoribus usque ad 23 cm. longis et 4.5 cm. latis margine crenatis subtus dense pilosis; sori confluentes; sporangiorum pedicellus apice setosus.

Type in herbarium of the New York Botanical Garden, collected in the valley of the Rio Corumba, State of Goyaz, Brazil, July 23, 1894, by M. A. Glaziou (no. 22631). Duplicates of this collection are at Copenhagen and Field Museum. Other specimens are as follows:

British Guiana: *Appun* 844 (K, 3 sheets).

Brazil: State of Bahia, *Blanchet* 1023 (Y). Matto do Curupira, State of Matto Grosso, *Lindman* A 3043 (US). Without locality, *Riedel* 59 (US).

This variety differs from the typical form of *D. chrysodioides* in its larger and more numerous sterile pinnae and in its strongly crenate fertile pinnae. From *D. membranacea*, which in some ways it resembles, it differs in having the fertile pinnae smaller than the sterile and conspicuously crenate, and in its confluent sori.

DOUBTFUL AND EXCLUDED SPECIES

Meniscium cristatum Desr. in Lam. Encycl. **4:** 94. 1797.

This is *Diplazium cristatum* (Desr.) Alston, Journ. Bot. Brit. & For. **74:** 173. 1936.

Meniscium Fendleri Eaton ex C. Chr. Ind. Fil. 421. 1906.

According to Christensen the citation is Bot. Gaz. **3:** 89. 1878, but no such name appears at this place. The species is *Bolbitis macrophylla*.

Meniscium guyanense Fée, Gen. Fil. 224. 1852.

This is *Bolbitis macrophylla*.

Meniscium "puncta lunulatum Rich." ex C. Chr. Ind. Fil. 421. 1906.

At the place cited by Christensen, viz., Act. Soc. Hist. Nat. (Paris) **1:** 114. 1792, this is by no means intended as a species name but is merely the first part of the generic description of *Meniscium* given by Richard.

Bolbitis macrophylla (Kunze) Maxon & Morton, comb. nov.

Meniscium macrophyllum Kunze, Flora **22**[1]: Beibl. 44. 1839.
Heteroneuron meniscioides Fée, Hist. Acrost. 93. *pl. 55*. 1845.
Poecilopteris meniscioides Presl, Epim. Bot. 175. 1851.
Meniscium guyanense Fée, Gen. Fil. 224. 1852.
Phegopteris macrophylla Mett. Fil. Lechl. **2**: 24. 1859.
Nephrodium macrophyllum Keys. Pol. Cyath. Herb. Bung. 48. 1873.
Acrostichum Fendleri Baker, Journ. Bot. Brit. & For. **25**: 100. 1887.
Meniscium oligophyllum Hort. ex Baker, Ann. Bot. **5**: 487. 1891.
Leptochilus Fendleri C. Chr. Bot. Tidsskr. **26**[2]: 285. 1904.
Dryopteris macrophylla C. Chr. Ind. Fil. Suppl. I. 35. 1913.
Dryopteris anceps Maxon, Contr. U. S. Nat. Herb. **24**: 62. 1922.

Close study of a large series of specimens convinces us that this species may not be retained in *Dryopteris*. The sporangia are not borne on a definite receptacle, as in all species of that genus, but are regularly distributed over the whole leaf surface. A few species of *Meniscium*, such as *D. chrysodioides*, are so heavily fertile that in age the sporangia appear to cover the whole leaf surface, but a careful dissection shows that the stalks always arise on the arcuate cross-veins and never from the leaf tissue between the veins.

In the Trinidad specimens and in most of those from British Guiana the sporangium wall is conspicuously setose. This is not true for most of the Brazilian material. However, this variation is not found to be correlated with other differences, and we regard the entire series of specimens as conspecific.

The genus *Leptochilus* Kaulf.[21] is at present restricted by Ching and Christensen to a small group of Old World species considered to be of polypodioid rather than dryopteroid affinity. Most of the species formerly included in *Leptochilus* they place in *Bolbitis* Schott.[22] Within the latter polymorphic genus, as represented in tropical America, the present species is quite isolated by reason of its entirely meniscioid venation. None of the other American species have this venation, although an approach is found in several Old World species, notably in *B. subcrenata* (Hook & Grev.) Ching, of India and Ceylon. In that the venation is sometimes entirely meniscioid, although commonly the basal areole bears more than one excurrent venule. In other respects, however, *B. subcrenata* is widely different from our plant. The sterile blades of *B. macrophylla* resemble very strongly those of *Dryopteris chrysodioides*, but may be distinguished by their glabrous rather than hirsutulous rachises and their glabrous leaf tissue.

[21] Enum. Fil. 147. 1824.
[22] Gen. Fil. *pl. 14*. 1834.

Bolbitis macrophylla is rather widely distributed, and we have examined the following specimens:

TRINIDAD: L'Orange Road, *Hombersley* 226 (US). Brazil, *Britton, Britton, & Freeman* 2142 (US). Without specific locality, *Bot. Gard. Herb.* 1584 (US); *Fendler* 88, type of *Acrostichum Fendleri* (US, Y).

TOBAGO: Between Roxborough and Parlatuvier, *Broadway* 4904 (US).

BRITISH GUIANA: Barina River, *Jenman* (Y). Demerara River, *Jenman* (Y). Potaro River, *Jenman* 1449 (K). Without special locality, *Jenman* 2072 (K); *Appun* 732 (K).

FRENCH GUIANA: Acarouany (or Karouany), *Sagot* 1396 (B, K). Menonicia, *Leprieur* 70 (US).

BRAZIL: Serra do Mar, near Ilhéos, Bahia, *Martius* 363, type coll. (K, Y); *Blanchet* 2228 (K), 2477 (K). Bahia, *Luschnath* 82 (B). Para, *Pételot* (F). Tanaii, *Spruce* 32** (K). Sa do Mar, São Paulo, *Wacket* 211 (Y). Without special locality, *Riedel* 1292b (B); *Riedel* s. n. (C); *Riedel* 59, form with simple blades (US); *Glocker* s. n. (US).

PERU: Pongo de Manseriche, Loreto, *Mexia* 6202 (US).

VENEZUELA: Base of Mt. Cocui, *Spruce* 3030 (K).

MENISCIUM OPACUM Baker, Journ. Bot. Brit. & For. **15:** 166. 1877.

As stated in the introduction this species, properly known as *D. Christii* C. Chr., belongs to the subgenus *Stigmatopteris*.

MENISCIUM SALICIFOLIUM Presl, ex Ettingsh. in Denkschr. Akad. Wiss. Math. Naturw. (Wien) **23:** 93. 1864; Ettingsh. Farnkr. Jetzw. 169. *pl. 132, figs. 2, 7.* 1865 (non Wall. ex Hook. 1854).

Described from Brazil on characters of venation only. We are unable to identify the figure definitely, though it suggests *Dryopteris Salzmanni.* The plant is utterly different from the Old World *salicifolium* of Wallich, under which it is cited in the Index Londinensis.

UNITED STATES NATIONAL MUSEUM,
WASHINGTON, D. C.

The Taxonomy of a Community of Blue-Green Algae in a Minnesota Pond

HELEN FOOT BUELL

(WITH TWELVE FIGURES)

In a previous paper (Buell, 1938) the author described a fresh-water community of blue-green algae in Minnesota. In its early stages it is benthic in ooze in water 10 to 20 feet deep. Later it floats to the surface, buoyed up by gases liberated within the mass during photosynthesis.

This community is a globular mass whose outer portion is a thin, compact tegument composed almost exclusively of species of Oscillatoriaceae. The trichomes are arranged with their long axes parallel to the vertical axis of the mass. This tegument encloses a soft, oozy portion, forming the bulk of the mass. In this ooze are found chiefly unicellular pseudovacuolate Cyanophyceae.

The present paper is devoted to the Cyanophycean members of this community. Detailed discussions are given only of those forms believed to be new to science or which are otherwise significant.

METHODS

In the field small pieces of material were removed from different parts of the mass, in order to determine regional distribution of forms, and were preserved immediately in 3–4 per cent commercial formalin. Observations were also made on living material in order to offset any artifacts produced by the action of the preservative. The drawings were made from glycerine or glycerine gelatine mounts. Most of the figures were drawn to scale according to Tilden's (1934) method, and, with two exceptions, are reproduced at a magnification of 1000.

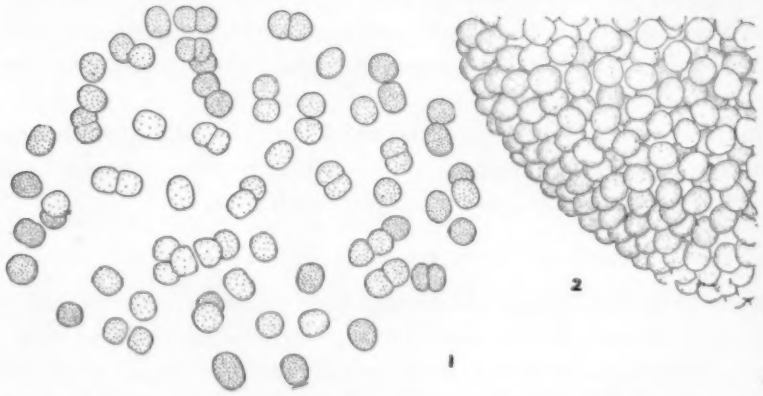
The type specimens have been deposited in the phycological laboratory of the botany department at the University of Minnesota.

CHROOCOCCACEAE

Microcystis pulverea (Wood) Migula (fig. 1) is found rarely in the interior portion of most communities. The size of the cells is from $1.6-2.0 \times 1.6-2.6\mu$, with an average of $1.7 \times 2.0\mu$. Authors (Wolle, 1887; Lemmermann, 1907; Forti, 1907; Tilden, 1910; Smith, 1920; Crow, 1923; Geitler, 1925, 1932) have described the cells of *M. pulverea* as ranging in size from 2 to 3μ. Lemmermann (1907), in establishing *M. incerta*, gave its size as $1–1.5\mu$, while Smith (1920) places the size at $1–2\mu$. Smith also states that since the difference between *M. pulverea* and *M. incerta* is "mainly one of

size it might be better to consider *M. incerta* a variety of *M. pulverea*." Crow (1923), following Smith's suggestion, says, "it therefore seems that the essential difference between the two forms is one of size and as it is not customary to establish species on this character alone we have regarded *M. incerta* as a variety of *M. pulverea*." Geitler accepts Crow's decision. However, in view of the fact that the sizes for species and variety are continuous, i.e., 1–2μ and 2–3μ, and also in view of the fact that the cells described here are intermediate in size between them, it seems better to consider *M. incerta* as synonymous with *M. pulverea*, the size range for the species then being 1–3μ.

Microcystis spp. In the interior of the community the dominant algae are pseudo-vacuolate species of *Microcystis*. These become very abundant



Figs. 1–2. Fig. 1. *Microcystis pulverea* (Wood) Migula. ×1000. Fig. 2. *Coelomoron regularis* H. F. Buell spec. nov. One fourth of colony, surface view. ×1000.

during the hot weather of August; a single microscope mount may show hundreds of colonies. Crow (1923) says, "whenever abundant material occurs the precise limits of the different species become impossible to define." The Minnesota material illustrates this fact, intergrading colony forms occurring between all the species present. The following species are definitely present: *M. protocystis* Crow, *M. viridis* (A. Braun) Lemm., *M. flos-aquae* (Wittr.) Kirchn., *M. marginata* (Menegh.) Kütz., and *M. aeruginosa* Kütz. These species are listed in the order of their abundance. All are present in algal masses throughout the season, but *M. protocystis* increases enormously in numbers during August. The species is described by Crow (1923) as having irregular, often diffuse colonies, with the plants generally dissociated. In this Minnesota material the colonies are very diffuse and the plants widely scattered. The abundance of this alga and its diffuse state are especially interesting in view of Naumann's (1925) in-

vestigations on the form of the colony (*M. aeruginosa*) in relation to water movement. He concluded that large colonies, in part clathrate, with diffluent gelatine and scattered cells, develop in quiet water; while small, compact colonies develop in moving water. In the interior of these algal masses, where there is a minimum of water movement, the most common species is that having the maximum degree of dissociation.

Coelomoron gen nov. Tegumentum prope aut in totum invisibile, achromaticum, tenue, diffluente; coloniae microscopicae, globosae, ellipticae, aut ovatae, principio solidae, tum denique cavae; plantae coloniarum maturarum peripherice ordinatae in strato 2–3 cellularum; cellularum divisio primo in omnem directionem, tum denique tantum in angulis dextris ad superficiem coloniae.

Tegument almost or entirely invisible, colorless, thin, diffluent; colonies microscopic, spherical, elliptical, or ovoid, at first solid, later hollow; plants of mature colonies peripherally arranged in a layer of 2–3 cells; cell division at first in all directions, later only at right angles to the surface of the colony.

The genus differs from *Microcystis* in that a hollow colony is formed at maturity, and from *Coelosphaerium* in that the plants are arranged in a layer 2–3 cells thick, instead of in a single layer.

Coelomoron regularis spec. nov. (figs. 2 & 3). Tegumento prope aut in totum invisibili, achromatico, tenui, diffluenti; coloniis microscopicis, globosis, ellipticis, aut ovatis; coloniis immaturis usque ad 30μ crassis, solidis; coloniis

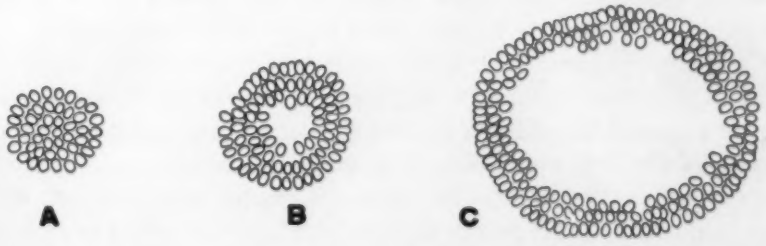


Fig. 3. *Coelomoron regularis* H. F. Buell spec. nov. Optical cross sections. *A*. Young colony. *B*. Older colony. *C*. Mature colony. Camera lucida drawings. ×375.

maturis cavis; plantis confertis compositis, peripherice ordinatis in strato 2–3 cellularum, globosis aut ovatis, saepe leviter planis propter mutuam pressuram praesertim in faciebus in angulis dextris ad superficiem coloniae; protoplasmate laete aeruginoso, sine pseudoracuolis. Tegumento 2–4μ crasso extrinsecus plantam. Coloniis usque ad 250μ, plerumque minus quam 100μ. Plantis 3–5μ diametro.

Tegument almost or entirely invisible, colorless, thin, diffluent; colonies microscopic, spherical, elliptical, or ovoid; immature colonies up to 30μ in

diameter, solid; mature colonies hollow; plants crowded, peripherally arranged in a layer of 2–3 cells, spherical or ovoid, often slightly flattened because of mutual pressure especially on the faces at right angles to the surface of the colony; protoplasm bright blue-green, without pseudo-vacuoles. Tegument 2–4μ thick outside of the plants. Colonies up to 250 μ, usually less than 100 μ in diameter. Plants 3–5μ in diameter.

Type locality: Mud in interior of algal mass, 10–20 feet of water, Lake of the Isles Lagoon, Minneapolis, Minn.

This alga is found occasionally as a rare to common constituent of the interior portion of the community. The colonies are remarkable for their "neat" compactness, and for the regular arrangement of the plants (Fig. 2), unlike anything found in *Microcystis*. The optical cross sections (Fig. 3) show the angularity of the cells, as well as successive stages in the formation of the interior cavity of the colony. The interior of the colony sometimes appears quite transparent and homogeneous; more often fine granulations are present, probably bacterial in nature.

Coelosphaerium Nägelianum Ung. is present in the interior of the community rarely or commonly. The development of the species is favored by the same conditions as favor the development of pseudo-vacuolate species of *Microcystis*.

Merismopedia species present in the interior core include *M. convoluta* Bréb., which is present rarely or commonly in practically all masses, *M. elegans* A. Braun and *M. glauca* (Ehrenb.) Näg., which are occasionally present, and *M. punctata* Meyen, which is rare to very abundant.

Merismopedia punctata[1] (fig. 4) is of special interest. It is one of those species (see Geitler, 1932) in which the long axes of the cells are parallel with the plane of the colony, instead of being at right angles to it. The diameter of the cells which is at right angles to the surface of the colony is approximately the same as the shorter diameter seen in surface view—about 2μ (fig. 4 E). This means that the plants are attached to each other by a very small area, as compared with the condition in such species as *M. convoluta*. Hence the plants break apart readily and the colonies

[1] As far as I have found, all references to this plant, beginning with Kützing (1849, p. 472), which state the place of publication, give it as Wiegmann's Archiv für Naturgeschichte **5**: 67, 1839. Earlier, however, Meyen (1829, pl. 43, fig. 36) had figured the plant but did not name it. In 1839 in his *Pflanzen-Physiologie* (pp. 440–441) he named and described the plant. During the same year in Wiegmann's Archiv für Naturgeschichte he referred to his naming and description of 1839, in his physiology, as having occurred prior to his brief comment in the Archiv. Hence, Pflanzen-Physiologie **3**: 440, 1839 is the original place of publication of the species *Merismopedia punctata* Meyen.

never attain any great size. Colonies having as many as 128 plants are rare; 32 is the usual maximum.

In the Minnesota material the cells are much more variable in size than as given by most authors—i.e., 2.5–3.5μ in diameter. The maximum range, including all stages of growth (see below), is .8–2.6×1.2–3.9μ. Even in the normal blue-green phase (fig. 4 A–D), the cells range in their greatest diameter from 1.8 to 3.9μ.

For the most part division and growth appear to be practically simultaneous in all plants of a colony, resulting in individuals of approximately

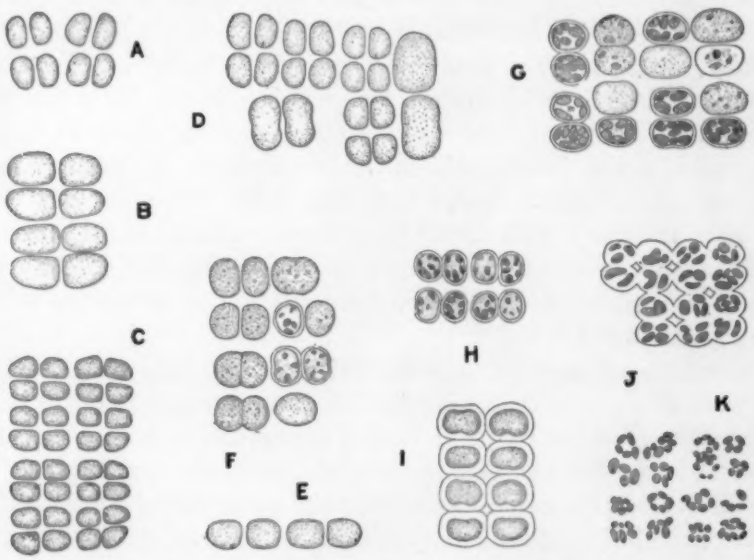


Fig. 4. *Merismopedia punctata* Meyen. *A–D.* Colonies showing arrangement and size of cells. *E.* Edge view of colony. *F–K.* Stages in vacuolation of colonies. ×2000.

the same size (fig. 4 A–C). Irregularities in size sometimes occur where "division rhythm" is lacking. In a few collections many colonies are found in which this rhythm is absent, and those cells in which the impulse toward division is absent continue to increase in bulk practically in unison with other pairs or groups of cells (fig. 4 D). Except for such comparatively rare instances, the colonies of this species show remarkably regular cell arrangement.

In normal vegetative condition the protoplasts are gray to pale blue-green, as Smith (1920) states. However, under some conditions the color and appearance change. Viewed under low and high powers of the microscope, each cell appears as a bright, rose-violet vacuole surrounded by a

hyaline blue sheath (fig. 4 I). Under oil immersion (fig. 4 H), however, the vacuolate portion appears to consist of large, bright, dark rose bodies (Klincksieck and Valette, 1908, colors 6–7, 27–28), imbedded in a straw-colored matrix (colors 103, 128). The exterior portion seems narrower than under high power, but retains its hyaline, blue, cartilaginous appearance. Frequently in one colony (fig. 4 F, G) there may be found stages in the development of the vacuolate condition from the normal bluish-green cells, showing conclusively that the former is but a phase of the latter. The homogeneously granular cell contents become coarsely granular; the background becomes faintly straw-colored; and the granules seem to aggregate in small groups, at first indistinct in outline. The exterior portion appears gradually, at first wider than later, and indistinctly limited within. Eventually all the cells in a colony become vacuolated (fig. 4 H). When conditions are such that these vacuolations form, the growth of the cells is decreased, but division continues. In consequence, the average size of these rose-colored cells is smaller than that of the blue-green cells, about $1.5 \times 2\mu$, as compared with $1.9 \times 2.5\mu$. Later the outline of the plants disappears, except around the outside of the colony (fig. 4 J), and still later this also disappears, and the colony consists merely of groups of rose-colored granules (fig. 4 K).

The nature and cause of the vacuolation of these cells is doubtful. The color, while resembling that found in blue-green algae supposed to possess phycoerythrin, has less purple in it, and the normal vegetative cells have none of the gray-violet tint characteristic of these algae, nor is there ever any evidence of pigment diffusing into the surrounding water. Neither have the vacuolations the familiar appearance characteristic of the pseudo-vacuoles found in such planktonic forms as *Microcystis flos-aquae;* and, in addition, while masses of the latter species appear pale yellow-green or cream-color, masses of *Merismopedia punctata* are bright rose-purple. There seems to be no doubt, however, that these vacuolations, like the pseudo-vacuoles of *Microcystis* (Van Goor, 1925) contribute to the buoyancy of the colony, as in mounts of the material the blue-green colonies sink to the slide, while the vacuolate colonies float at the upper surface of the medium. And, although the appearance of the plants is quite unlike that of pseudo-vacuolate planktonic algae, it seems probable that the vacuoles are physiologically similar, since they respond similarly to treatment with acid (Van Goor, *op. cit.*). By treating material of *M. punctata* with acid (a few drops of HCl or acetic acid added at the edge of the cover glass), the vacuolations are made to disappear, and cells such as those shown in figure 4 H assume the color and appearance of the blue-green stage; at the same time the colonies sink and rest on the slide.

That the vacuolation of these algae is a stage in the process of disintegration seems likely. This conclusion is reached in view of the retarding or cessation of growth in vacuolate colonies, the ultimate breaking up of the plants into separate granules, and the fact that in the laboratory they form a flocculent purple scum on the surface of material which has been standing some days in a warm room and which is well advanced in disintegration. The conditions causing vacuolation are peculiar to the individual community, since on the same day one collection may show chiefly non-vacuolate and another chiefly vacuolate colonies of *M. punctata*.

With regard to the position of *M. punctata* within the genus, it should be noted that there is a sharp distinction between this species and *M. convoluta* in respect to the direction of elongation of the cells. If we accept as valid Troitzkaia's (1922) separation of *Coccopedia* from *Holopedia* on the basis of the former having round cells, while the latter has cells elongated at right angles to the plane of the colony, then it would seem equally proper to separate into a new genus *M. punctata* and related species which have the long axes of the cells parallel with the plane of the colony. On the other hand, in view of the gradations that exist between the genera of the plate-forming Cyanophyceae (*Merismopedia*, *Coccopedia*, *Holopedia*), there is the opinion of Ryppowa (1925) to consider. He places these groups as subgenera of the single genus *Merismopedia*. It would thus seem reasonable to separate into a subgenus those members of the genus *Merismopedia* (as generally understood) which have their long axes parallel to the plane of the colony.

Next, the synonymy given by Geitler (1932) is to be considered. He says: "Inc. *M. paludosa* Bennet, Journ. R. Micr. Soc. P. 4, Taf. 1, Fig. 1, 1886?—*M. thermalis* Kützing, Tab. phyc. 5, Taf. 38.—*M. convoluta* f. *minor* Wille, Alg. Zentrales, Sven Hedin, 1922.—*M. glauca* var. *fontinalis Hansg.*, Prodr. Alg. Fl. Böhmen, 2, S. 141, 1892."

After examination of Bennett's (1886) article, it appears to me impossible to include *M. paludosa* with *M. punctata:* the cells, according to Bennett, have a diameter of 12.5μ; Bennett himself questioned whether or not the plant belonged to the genus *Merismopedia;* and his figure indicates that he probably had a species of *Tetrapedia*.

Kützing's (1849) *M. thermalis*, judging from its size and general description, may perhaps be synonymous with *M. punctata*.

It seems doubtful if *M. convoluta* f. *minor* Wille (1922) can be included with *M. punctata* as the size is incorrect. Wille says: "Long. cell 4–5μ, lat. 2–3μ." Even in the abnormally large cells in which division has failed to occur (see above) the largest size of *M. punctata* found in my material

is 3.9μ. Wille's figure represents plants which strongly resemble *M. convoluta*.

Whether or not *M. glauca* var. *fontinalis* Hansgirg (1892) should be included with *M. punctata* it is difficult to determine from the description.

The following paragraphs take up the question of synonymy as it appears to me.

In its vacuolate stage *M. punctata* agrees well with Wittrock's (1889) description of *M. chondroidea* Wittr. in the matter of color, granulation, wall characters, size of cells, and character of the colony.[2] Geitler (1925) separates *M. chondroidea* from *M. punctata* on the basis of the presence of vacuoles in *M. chondroidea*, although he says that it probably does not belong to the genus *Merismopedia*. Geitler (1932) says that *M. chondroidea* is an aberrant form which is best removed from the genus.

A specimen from Wittrock's material[3] has been examined and compared with the Minnesota material. Most of Wittrock's material consists of blue-green cells which appear to be typical *M. punctata*. Only a few colonies are present in which some or all of the cells are vacuolate. These, however, appear to be quite typical of the vacuolate phases found in the Minnesota collections of *M. punctata*. In the latter material vacuolate cells, when soaked up after having been dried, usually are blue-green in color, only occasional cells retaining their vacuolations and rose color. In view of these facts, I am convinced that the alga which Wittrock named *Merismopedia chondroidea* is a phase of *M. punctata* Meyen.

Closely similar to *M. punctata* is another species of *Merismopedia*—*M. tenuissima* Lemm. Lemmermann (1898) described it as having cells 1.3–2μ in size, pale blue-green, closely compressed into families of 16 cells. Smith (1920) and Geitler (1932) state that the number of cells in a colony is 16 to 100. Geitler separates this species from *M. punctata* on the basis of cell size, *M. tenuissima* having cells 1.3–2μ in diameter, while *M. punctata* has cells 2.5–3.5μ in diameter. Nevertheless, in the Minnesota material the range of cell sizes—1.2–3.9μ—includes the sizes given by Geitler for both *M. punctata* and *M. tenuissima*. Smith (1920) distinguishes between these two species on the basis of the distance between cells, *M. tenuissima* having the cells closely compressed and *M. punctata* having the cells "some distance from one another." His figures agree with this

[2] "M. cellulis cytioplasmate purpurascente-violaceo, granulis, sulphuraceis nullis, membrana crassa quasi chondroidea; diametro cellularum sphaericarum 2, 4-2, 6μ; coenobiis 4 vel 8-(rarius 2, 12, 16) cellularibus, in glomerulos saturate violaceos, forma indefinita, in superficie aquae demum natantes coacervatos."

[3] Wittrock and Nordstedt, no. 200, kindly supplied by the late Dr. M. A. Howe of the New York Botanical Garden.

statement. In a later publication, however, Smith (1924) figures a colony of *M. tenuissima* having cells farther apart than those shown in his 1920 figure of *M. punctata*. And Fritsch (1912) figures *M. tenuissima* with cells both close together and wide apart. In the Minnesota material some colonies are found which agree with Smith's (1920) figure of *M. tenuissima*, others which agree with his figure of *M. punctata*, and many which are intermediate. Hence, it appears probable that *M. tenuissima* and *M. punctata* are synonymous.

Lemmermann (1900) described another species, *M. Marssonii* Lemm., having many similarities with *M. tenuissima*, but distinguished from it by the presence of gas vacuoles, which, however, disappeared on treatment with acids. In view of what has been said with regard to the relation between the blue-green phase of *M. punctata* and its vacuolate stage, which has been described as *M. chondroidea*, there seems little doubt that Lemmermann's *M. Marssonii* is the vacuolate phase of his *M. tenuissima*. If this be true, it then seems that *M. Marssonii* Lemm. and *M. punctata* Meyen are synonymous.

Bachmann (1920) described still another vacuolate species, *M. Trolleri*. The plants formed a dull violet mass which was driven on to the beach by the wind. The colonies were 8-celled, sometimes 16-celled. The cells were 2–3μ in diameter, each cell possessing a thick sheath. The contents consisted of wine-red granules, "die oft in die Hülle herausquellen." Except that the size of these plants is a trifle larger than the average size of the vacuolate plants of *M. punctata*, Bachmann's description and figures fit very well the vacuolate phase of *M. punctata*. The expression "Kügelchen, die oft in Hülle herausquellen" appears to be descriptive of such a stage as is pictured in this paper in figure 5 J, K, when disintegration of the plants is well advanced. While in the Minnesota material the algae do not as a rule occur in macroscopic masses, they do occasionally; in laboratory cultures quantities of *M. punctata* at times form a dirty violet scum at the water surface; and in the stagnant arm of a lake in western Wisconsin I have found the vacuolate phase of *M. punctata* producing just such masses as Bachmann describes. In view of these facts, it appears probable that *M. Trolleri* is the same as *M. punctata*.

Holopedia geminata Lagerh. is present in the interior of communities occasionally, sometimes common, especially when in company with *Merismopedia convoluta*.

Holopedia pulchella spec. nov. (fig. 5). Coloniis minutis; plantis irregulariter dispositis, confertis compositis, polygonie planis; protoplasmate laete aeruginoso; plantis 2.5–4.8μ diametro (facies coloniae), 3.4–5.3μ longitudine (extremitas coloniae).

Colonies small; plants irregularly placed, closely compressed, polygonally flattened; protoplast bright blue-green; plants 2.5–4.8μ in diameter) surface of colony,) 3.4–5.3μ long (edge of colony).

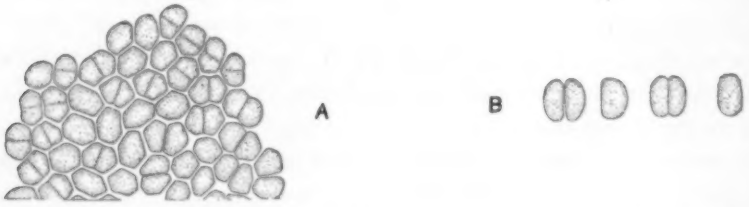


Fig. 5. *Holopedia pulchella* H. F. Buell spec. nov. *A*. Portion of surface of colony. *B*. Longitudinal views of cells. ×1000.

Type locality: Mud in interior of Cyanophycean algal mass, 10–20 feet of water, Lake of the Isles Lagoon, Minneapolis, Minn.

Occurrence: *Holopedia pulchella* is rare, or occasionally common, in the interior portion of the community, usually in company with *H. geminata* and *Merismopedia convoluta*.

Remarks: *H. pulchella* differs from the most closely related species, *H. sabulicola* Lagerheim, in four particulars: 1) colonies unattached; 2) colonies living in fresh water; 3) plants crowded; 4) plants smaller.

Lagerheim (1883) found *H. sabulicola* in the Baltic Sea, attached to grains of sand along with species of *Merismopedia*. The Minnesota material has been compared with a fragment from Lagerheim's specimen.[4] The plants are similar in general appearance, except that in *H. pulchella* they are more crowded and angular, and are considerably smaller than in

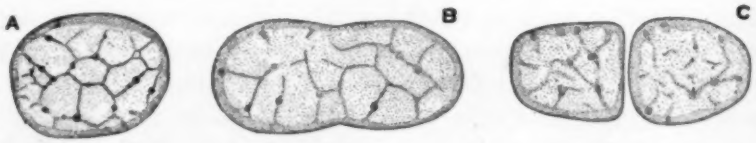


Fig. 6. *Synechococcus aeruginosus* Nägeli. ×1000.

H. sabulicola. The latter is described by Lagerheim as having cells 6μ long, and in his dried material they have been found to be 6–6.8μ in length.

Synechococcus aeruginosus Nägeli (Fig. 6) is rare or common in the interior portion of most masses. The plants are from 13 to 16μ in diameter. The color is a pale greenish-gray, and the general appearance is like that

[4] Wittrock, Nordstedt, and Lagerheim no. 1549, kindly furnished by the late Dr. M. A. Howe.

shown by Geitler (1932). The pigments, however, instead of being peripheral, seem to be in the interior of the cell, where they are confined to anastomosing strands. At intervals in the pigmented strands the granular substance is aggregated into larger masses which stand out brightly from the rest of the cell substance. The pronounced differentiation of the protoplasm into pigmented and unpigmented areas, and particularly the interior pigmented strands, is distinctive. It is true that Chodat (1896) found a pigmented central network in *Chroococcus turgidus* (Kütz.) Näg., and Crow (1922) refers to Chodat's work and also speaks of "shining globules of pigment within the cell" of some species of *Chroococcus*. While their words might seem to be in some measure descriptive of *Synechococcus aeruginosus*, nevertheless, as far as I have observed, and as far as available figures indicate, the appearance of the protoplast of *Chroococcus turgidus* is quite unlike that of *Synechococcus aerguinosus*. Indeed the distribution of pigments in the latter plant is much more suggestive of that in the red alga *Porphyridium* (Geitler, 1924) with its stellate, central chromatophore with strands reaching out to the periphery of the cell.

OSCILLATORIACEAE

Spirulina aeruginea spec. nov. (Section *Arthrospira* Geitler) (fig. 7). Strato viride-nigro; trichomatibus in spiras laxas regulares, vertes ab latere dextro ad latus sinistrum, apicibus gradatim attenuatis, ad dissepimenta haud constrictis; dissepimentis plerumque distinctis, interdum granulatis; cellulis diametro brevioribus cellula apicali plerumque diametro longiore; protoplasmate tenui-granuloso, ad dissepimenta crasse granulato, laete aeruginoso; spiris 9.5–18μ crassis, 14–24μ inter versationes; cellulis 3.9–5.7$\times$ 3.5–5μ.

Plant mass greenish black; trichomes in loose regular spirals, turning from right to left,[5] gradually tapered at the apex, not constricted at the transverse

Fig. 7. *Spirulina aeruginea* H. F. Buell spec. nov. $\times$1000.

septa; transverse septa usually distinct, sometimes granulated; cells shorter than their diameter; apical cell usually longer than the diameter; protoplasm finely granular, at the transverse septa sometimes coarsely granulated, bright

[5] In speaking of the direction of the spiral, the reference is to the direction as seen *under the microscope*, where of course the apparent direction is the reverse of the actual.

blue-green;[6] spirals 9.5–18μ broad, 14–24μ between turnings; cells 3.9–5.7$\times$ 3.5–5μ.

Type locality: Outer layers of Cyanophycean algal mass, 10–20 feet of water, Lake of the Isles Lagoon, Minneapolis, Minn.

Occurrence: *Spirulina aeruginea* is one of the characteristic and distinctive members of the community. With its allied species, *S. amethystina* H. F. Buell, and species of *Oscillatoria*, it forms the outer layers of the mass. During the summers of 1929 and 1930, *S. aeruginea* was more abundant than *S. amethystina* until the latter part of the season. Throughout the season of 1931, when beginning early in the summer the temperatures were unusually high, *S. aeruginea* was much less abundant than *S. amethystina*.

Remarks: *Spirulina aeruginea* is distinguished from *S. Jenneri* (Hassall) Kützing[7] in three particulars: 1) the diameter of the trichome—3.9–5.7μ—is somewhat less than in *S. Jenneri*, whose diameter is given as 5–8μ; 2) the extremity of the trichome tapers, while the trichome of *S. Jenneri* is untapered; 3) the spiral has a clockwise direction, while in *S. Jenneri* it has a counter-clockwise direction.

With regard to the direction of spiraling in the genus *Spirulina*, there is little information in the literature. Many of the earlier published figures do not indicate a spiral. No authors, as far as I know, state whether or not they consider the direction of spiraling constant in the species they describe. Geitler (1925) says that the direction of spiraling should be used as a diagnostic character, indicating that he considers it constant. In most of the published figures of *S. Jenneri*, including the widely copied drawing by Gomont (1892), the plant is drawn as if the entire body of the trichome lay in a single plane. As far as I have been able to discover, the only delineators who have indicated the direction of the spiral are Hassall (1845), Wolle (1887), Crow (1924), Frémy (1930) and Moore.[8] All of these

[6] Klincksieck and Valette (1908) colors 336, 342.

[7] The specific name of this plant is variously credited—rarely to Hassall, generally either to Kützing or to Stizenberger. The first use of the name, however, appears to have been by Hassall (1845) in *Spirillum Jenneri*. Kützing (1846, 1849) used the name *Spirulina Jenneri* Kützing. Stizenberger (1852) placed Hassall's plant in his new genus *Arthrospira*. Gomont (1892), the universally accepted authority on the Oscillatoriaceae, gives the name *Arthrospira Jenneri* Stizenberger, but in his list of synonyms gives *Spirillum Jenneri* Hassall and *Spirulina Jenneri* Kützing. Hence if the genus *Arthrospira* is retained, the name of the species is *Arthrospira Jenneri* (Hassall) Stizenberger; while if it is returned to the genus *Spirulina*, the name is *Spirulina Jenneri* (Hassall) Kützing.

[8] Moore, Marjorie Forbes—Department of Botany, University of Minnesota, unpublished observations.

indicate a counter-clockwise, or left to right, spiral. Likewise I have found in collections of bottom sand from the littoral region (10–20 cm.) in Lake of the Isles Lagoon typical *S. Jenneri* having counter-clockwise spirals. Consequently there is little doubt that a counter-clockwise direction of spiraling is characteristic of *S. Jenneri*. A clockwise direction of spiraling is definitely characteristic of *S. aeruginea*.

Spirulina amethystina spec. nov. (Section *Arthrospira* Geitler) (fig. 8). Strato levi nigro aut rubro; trichomatibus in spiras laxas regulares, vertes ab latere dextro ad latus sinistrum, apicibus gradatim attenuatis, ad dissepimenta haud constrictis; dissepimentis plerumque distinctis, interdum granulatis; cellulis diametro brevioribus; cellula apicali plerumque diametro longiore; protoplasmate tenui-granuloso, ad dissepimenta interdum crasse granulato, viride-cinereo aut violaceo; spiris 9.5–18μ crassis, 14–24μ inter versationes; cellulis 3.9–5.7×3.5–5μ.

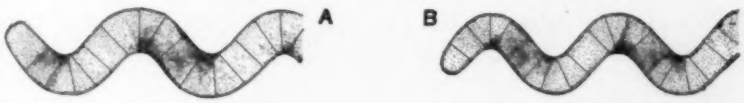


Fig. 8. *Spirulina amethystina* H. F. Buell spec. nov. ×1000.

Plant mass soft black or red; trichomes in loose regular spirals, turning from right to left,[9] gradually tapered at the apex, not constricted at the transverse septa; transverse septa usually distinct, sometimes granulated; cells shorter than their diameter; apical cell usually longer than the diameter; protoplasm finely granular, at the transverse septa sometimes coarsely granulated, grayish green to violet;[10] spirals 9.5–18μ broad, 14–24μ between turnings, cells 3.9–5.7×3.5–5μ.

Type locality: Outer layers of Cyanophycean algal mass, 10–20 feet of water, Lake of the Isles Lagoon, Minneapolis, Minn.

Occurrence: *Spirulina amethystina* is one of the dominant members of the association which forms the outer layer of the mass. It is most abundant during extremely hot weather.

Remarks: This species is distinguished from *S. aeruginea* by its gray to violet color, instead of a typical blue-green color. While in the grayer phase of pigmentation of *S. amethystina* the purple tint is not noticeable, and while there are indistinguishable gradations from green-gray to distinct purple or violet, nevertheless there is no gradation in color between the green-gray of *S. amethystina* and the bright blue-green of *S. aeruginea*.

[9] In speaking of the direction of the spiral, the reference is to the direction as seen *under the microscope*.

[10] Klincksieck and Valette (1908) colors 498, 517, 522, 533, 538, 548, 572.

The difference in color is striking in cases where trichomes of the two species twine about one another. It is probable that the purple color of *S. amethystina* is due to the presence of phycoerythrin, and that this pigment is entirely lacking in *S. aeruginea*. In view of this probability, and in view of the increasing tendency (Tilden, 1928) to consider pigmentation in the algae as a fundamental, elemental character of the organism, it seems desirable to consider *S. amethystina* as a distinct species.

With regard to the pigmentation of *S. amethystina*, one feature is of interest in connection with the theory advanced by Crow (1922, 1928) that the trichome of the Oscillatoriaceae is homologous with the single cell of the Chroococcaceae. While there is a wide variation in color from trichome to trichome, the color is constant within the individual trichome throughout its entire length, however great. There are also other indications that the trichome is the unit of structure in both *S. amethystina* and *S. aeruginea;* there is practical uniformity throughout the trichome in the degree of granulation of the protoplasm in both living and preserved plants; and there is considerable uniformity in the visibility of the transverse septa.

One point should be mentioned, however, which Crow (1928) makes in support of his theory of the homology between trichomes and unicellular plants. Of the genus *Arthrospira* he says: "The plants retain their hormogonial aspect throughout their life. The filaments of *Arthrospira* are, like those of *Spirulina*, amongst the shortest adult forms occurring in the family Oscillatoriaceae." Nevertheless, in *S. amethystina* and *S. aeruginea* the trichomes are fully as long as are those of accompanying species of *Oscillatoria* having a similar diameter. In any case, trichomes attaining a length of 1–2 mm., as are common in these two species of *Spirulina*, can hardly be said to have a "hormogonial aspect."

Species of *Oscillatoria* present in the exterior layers of the community are *O. geminata* Menegh., *O. amphibia* Agardh, *O. limosa* Agardh, *O. Mougeotii* Kütz., *O. tenuis* Agardh, *O. princeps* Vaucher, forma *maxima* (Kütz.) Rabenh. and forma *tenuior* Rabenh., *O. terebriformis* Agardh, *O. formosa* Bory, *O. Okeni* Agardh, and *O. chalybea* Mertens. All of these, except the last, are present in variable numbers, being rare to common. *O. chalybea*, however, is always present in considerable amount, and in masses which are blue-green or blackish-green in color, it is generally the dominant species in the outer layers. In addition there are present the following forms which are believed to be new to science.

Oscillatoria amethystina. spec. nov. (fig. 9). Strato levi nigro aut rubro; trichomatibus rectis, flexilibus, ad dissepimenta plus minusve constrictis, gradatim attenuatis ad longinquitatem ab apiculo; apiculo uncinato aut arcu-

ato; cellula apicali obtuso haud capitata, haud calyptrata; cellulis subquadratis vel brevioribus; cellula apicali plerumque diametro longiore; protoplasmate tenui-granuloso, ad dissepimenta plus minusve crasse granulato, viridecinereo aut violaceo; cellulis 3.5–5×2–3.5μ.

Plant mass soft black to red; trichomes straight, flexuous, more or less constricted at the transverse septa, gradually tapering for a long distance from the apex; apex hooked or curved; apical cell rounded, not capitate, not calyptrate; cells subquadrate or shorter; apical cell usually longer than the diameter; protoplast finely granular, more or less coarsely granulated at the transverse septa, greenish-gray to violet;[11] cells 3.5–5×2–3.5μ.

Type locality: Outer layers of Cyanophycean algal mass, 10–20 feet of water, Lake of the Isles Lagoon, Minneapolis, Minn.

Fig. 9. *Oscillatoria amethystina* H. F. Buell spec. nov. *A*. Terminal and median portions of a trichome. *B*. Portion of old, disintegrating trichome. ×1000.

Occurrence: *O. amethystina* is rare or common in the exterior portions of masses throughout the season, but is most abundant during the hottest weather.

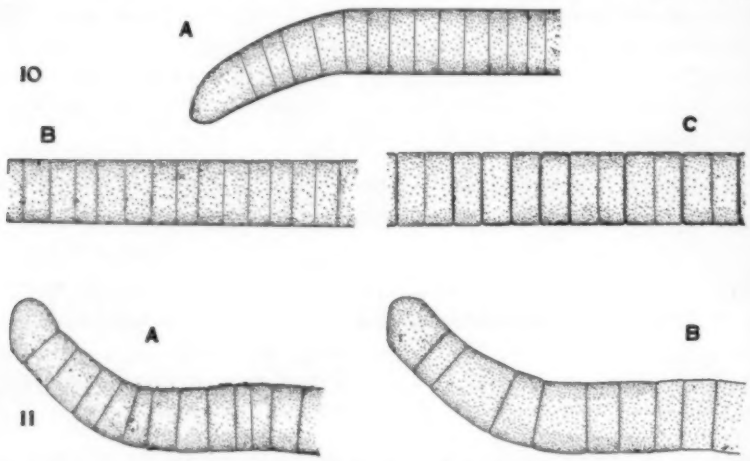
Remarks: This species appears to resemble most closely *O. violacea* (Wallr.) Hass., which has violet to blue-green trichomes, 4–4.5μ in diameter. However, *O. violacea* is described as being sharply pointed at the apex, while *O. amethystina* does not taper to a sharp point, but is rounded at the apex. The appearance of the apical cell itself is much like that of the apical cell of *O. formosa* Bory, but in *O. amethystina* the tapering is greater and much more gradual. The trichome is usually much less constricted in the apical than in the median portion (fig. 9 A). The color of the plant is like that of *Spirulina amethystina*.

Oscillatoria Leavittae[12] spec. nov. (figs. 10, 11). Strato levi nigro aut rubro; trichomatibus rectis, ad dissepimenta plus minusve constrictis, gradatim attenuatis ad longinquitatem ab apiculo; apiculo uncinato aut arcuato; cellula apicali conica, plerumque leviter plana a parte superiore lateris convexi, haud capitata, haud calyptrata; cellulis diametro brevioribus, cellula apicali plerumque diametro longiore; protoplasmate tenui-granuloso, viridecinereo aut violaceo; cellulis 7.5–11.5×3–7μ; cellulis apicalibus usque ad 11μ longis.

[11] Klincksieck and Valette (1908) colors 498, 517, 522, 533, 538, 548, 572.

[12] This handsome species is named in honor of Miss Clara K. Leavitt, who discovered and first studied the community in which the plant grows.

Plant mass soft black or red; trichomes straight, more or less constricted at the transverse septa, gradually tapering for a long distance from the apex; apex hooked or curved; apical cell conical, usually flattened on the upper portion of the convex side, not capitate, not calyptrate; protoplast finely granular, greenish-gray to violet;[13] cells 7.5–11.5×3–7μ; apical cell up to 11μ long.



Figs. 10–11. Fig. 10. *Oscillatoria Leavittae* H. F. Buell spec. nov. *A*, *B*, *C*. Terminal, subterminal, and median portions respectively of one trichome. ×1000. Fig. 11. *Oscillatoria Leavittae* H. F. Buell spec. nov. Variations in apices of trichomes. ×1000.

Type locality: Outer layers of Cyanophycean algal mass, 10–20 feet of water, Lake of the Isles Lagoon, Minneapolis, Minn.

Occurrence: *O. Leavittae* is the dominant species in the exterior portion of reddish black or red masses. It is most abundant during the hottest weather of the summer.

Remarks: In the size of the trichomes *O. Leavittae* is similar to *O. chalybea*, whose trichomes are 8–13μ in diameter. The gradual tapering characteristic of the new species also is similar to the condition usually described for *O. chalybea*. The latter species,[14] however, is described as having an obtuse apical cell, while *O. Leavittae* is characterized by a conical apical cell, peculiarly flattened on the upper portion of the convex side. Also the color is distinctive, there being as great a difference between the color of *O. Leavittae* and *O. chalybea* as there is between that of *Spirulina amethystina* and *S. aeruginea* (see above). The color is like that of *Spirulina amethystina* and *Oscillatoria amethystina*, and as in these two species, the color is most pronounced in the hottest weather.

[13] Klincksieck and Valette (1908) colors 498, 517, 522, 533, 538, 548, 572.

[14] Gomont (1892) says, "apicem versus breviter aut longe et sensim attenuata"; Frémy (1930) says, "longuement et insensiment atténués vers leurs extrémités." Both authors, however, figure a brief tapering.

The characters of the apical portion of the trichome are, of course, more or less variable, apparently depending on the amount of growth since breakage or formation of hormogones has occurred. Thus if a trichome has been recently broken, considerable growth must take place before the new apex becomes gradually tapered. Hence, for a time the apical cell will be more or less obtuse; but it soon acquires the characteristic flattening on the upper side of the curve (fig. 11).

In this plant, as in *O. chalybea*, there is usually a decided difference in long trichomes between the median and apical portions, The trichome is not merely wider in its median portion, it is also more strongly constricted (fig. 10 A, B, C), the protoplast is more coarsely granular, and the color is generally more pronounced. Apparently younger, actively growing portions of the trichome are greenish-gray, the red pigment being more abundant, or at least more evident, in older cells. The lack of uniformity shown by *Oscillatoria amethystina*, *O. Leavittae*, and *O. chalybea* as to constrictions, granulations and coloring of individual trichomes is in striking contrast with the condition shown by *Spirulina aeruginea* and *S. amethystina* (see above).

Species of *Anabaena* are present occasionally in the interior mud of the community. These include the pseudo-vacuolate species *A. planctonica* Brunnth, and *A. spiroides* Kleb., and two others, which in the absence of gonidia can not be identified.

Also *Anabaena constricta* (Szafer) Geitler (fig. 12) is present in prac-

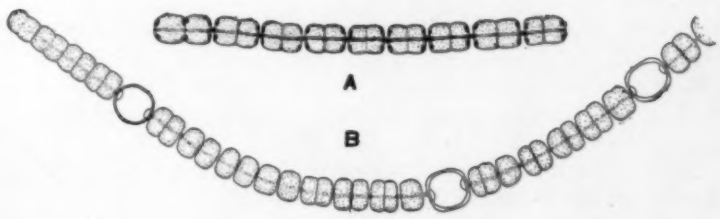


Fig. 12. *Anabaena constricta* (Szafer) Geitler. *A*. Filament without heterocysts. *B*. Filament with heterocysts. ×1000.

tically all communities, sometimes commonly. The vegetative cells are 5–7×6–10μ. The colorless central portion of the filament has the appearance of a thread with beads strung on it. This "thread" is continuous from cell to cell, but it is very fragile and breaks readily; hence one rarely finds filaments composed of more than 15 or 20 cells. Geitler (1932) states that only two heterocysts (in one filament) have thus far been found (Koppe, 1924). Examination of hundreds of filaments in this material has disclosed one filament with three heterocysts (fig. 12 B). These

have a diameter of 5–6μ and a length of 6–6.5μ. Koppe reported a diameter of 5μ.

SUMMARY

A description is given of the blue-green algae forming a freshwater community which develops in bottom ooze and later floats to the surface. One new genus is described—*Coelomoron*—a colonial member of the Chroococcaceae. New species described are *Coelomoron regularis*, *Holopedia pulchella*, *Spirulina aeruginea*, *S. amethystina*, *Oscillatoria amethystina*, and *O. Leavittae*, the last three of which are characterized in part by red pigmentation. *Merismopedia chondroidea* Wittr. is shown to be synonymous with *M. punctata* Meyen.

This work was done in the botanical laboratories of the University of Minnesota.

DEPARTMENT OF BOTANY,
NORTH CAROLINA STATE COLLEGE,
RALEIGH, N. C.

Literature cited

Bachmann, H. 1920. *Merismopedia Trolleri* nov. spec. Zeits. Hydrologie (Revue d'Hydrologie) **1**: 350.

Bennett, A. W. 1886. Fresh-water algae (including chlorophyllaceous Protophyta) of the English Lake District: with descriptions of twelve new species. Jour. Roy. Micr. Soc. II. **6**: 1–15.

Buell, H. F. 1938. A community of blue-green algae in a Minnesota pond. Ecology **19**: 224–232.

Chodat, R. 1896. *Chroococcus turgidus*. Nuova Notarisia. 98.

Crow, W. B. 1922. A critical study of certain unicellular Cyanophyceae from the point of view of their evolution. New Phyt. **21**: 81–102.

————. 1923. The taxonomy and variation of the genus *Microcystis* in Ceylon. New Phyt. **22**: 59–68.

————. 1924. Variation and species in Cyanophyceae. Jour. Genetics **14**: 391–424.

————. 1928. The morphology of the filaments of Cyanophyceae. Ann. Protist. **1**: 19–36.

Forti, A. 1907. Sylloge Myxophycearum. In, De Toni, J. B. Sylloge Algarum Omnium. Vol. 5.

Frémy, P. 1930. Les Myxophycées de l'Afrique équatoriale française. Arch. de Botanique Caen, Vol. 3 (mém. 20).

Fritsch, F. E. 1912. Freshwater algae. National Antarctic Expedition. Natural History **6**: 1–60.

Geitler, L. 1924. Ueber einige wenig bekannte Süsswasserorganismen mit roten oder blaugrünen Chromatophoren. Zugleich ein Beitrag zur Kenntnis pflanzlicher Chromatophoren. Rev. Alg. **1**: 357–375.

———. 1925. Cyanophyceae. In, A. Pascher. Die Süsswasser-Flora Deutschlands, Oesterreichs und der Schweiz. Heft 12.

———. 1932. Cyanophyceae (Blaualgen). In, L. Rabenhorst's Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz. Vol. 14.

Gomont, M. M. 1892. Monographie des Oscillariées (Nostocacées Homocystées).

Hansgirg, A. 1892. Prodromus der Algenflora von Böhmen, Vol. 2.

Hassall, A. H. 1845. A history of the British freshwater algae.

Klincksieck, P., and Th. Valette. 1908. Code des couleurs à l'usage des naturalistes, artistes, commerçants et industriels.

Koppe, F. 1924. Die Schlammflora der ostholsteinischen Seen und des Bodensees. Arch. Hydrobiol. Planktonk. **14:** 619–672.

Kützing, F. T. 1846. Tabulae Phycologicae oder Abbildungen der Tange. Vol. 1.

———. 1849. Species Algarum.

Lagerheim, G. 1883. Bidrag till Sveriges algflora. Ofversigt Kongl. Vetenskaps-Akademiens Förhandlingar. No. 2. 37–38.

Lemmermann, E. 1898. Beitrage zur Kenntniss der Planktonalgen. II. Beschreibung neuer Formen. Bot. Centralbl. **76:** 150–156.

———. 1900. Beiträge zur Kenntniss der Planktonalgen. III. Neue Schwebalgen aus der Umgegend von Berlin. Ber. Deutsch. Bot. Ges. **18:** 24–32.

———. 1907. Algen. (Schizophyceen, Flagellaten, Peridineen.) In Kryptogamenflora der Mark Brandenburg. Vol. 3.

Meyen, F. J. E. 1829. Beobachtungen über einige niedere Algenformen. Nova Acta Acad. Caes. Leop.-Carol. **14:** 769–778.

———. 1839. Neues System der Pflanzen Physiologie. Vol. 3.

———. 1839. Jahresbericht über die Resultate der Arbeiten in Felde der Physiologischen Botanik von dem Jahre 1838. Archiv Naturgeschichte **5²:** 1–152.

Naumann, E. 1925. Notizen zur experimentellen Morphologie des pflanzlichen Limnoplanktons. I–II. Bot. Notiser. **1925:** 47–51.

Ryppowa, H. 1925. *Merismopedia* (subgenus *Pseudoholopedia*) *gigas* (nov. subgen. nov. sp.). Acta Soc. Bot. Poloniae **3:** 42–48. (Summary in Rev. Alg. **3:** 267–268.)

Smith, G. M. 1920. Phytoplankton of the inland lakes of Wisconsin. Part. 1. Myxophyceae, Phaeophyceae, Heterokonteae, and Chlorophyceae exclusive of the Desmidiaceae. Wisconsin Geol. and Nat. Hist. Survey. Bull. 57. Sci. Ser. 12.

———. 1924. Ecology of the plankton algae in the Palisades Interstate Park, including the relation of control methods to fish culture. Roosevelt Wild Life Bulletin **2:** 96–195.

Stizenberger, Dr. 1852. *Spirulina* und *Arthrospira* (nov. gen.). Hedwigia **1:** 32.

Tilden, J. E. 1910. Minnesota Algae. I. The Myxophyceae of North America and adjacent regions including Central America, Greenland, Bermuda, the West Indies and Hawaii.

———. 1928. Some hypotheses concerning the phylogeny of the algae. Am. Nat. **42:** 137–155.

———. 1934. Standardization of method for drawing algae for publication. Bot. Gaz. **95:** 515–518.

Troitskaia, I. V. 1922. A new genus of blue-green algae. Notulae Syst. Inst. Crypt. Hort. Bot. Petropolitani. **1:** 129–131.

Van Goor, A.-C.-J. 1925. Contribution à la physiologie des Cyanophycées. Sur les pseudo-vacuoles rouges et leur signification. Rev. Alg. **2**: 19–38.

Wille, N. 1922. Algen aus Zentralasien gesammelt von Dr. Sven Hedin. In, Southern Tibet. Discoveries in former times compared with my own researches in 1906–1908, by Sven Hedin. **6**(3)Botany: 155–195.

Wittrock, V., and O. Nordstedt. 1889. Algae aquae dulcis exsiccatae praecipue scandinavicae, quas adjectis algis marinis chlorophyllaceis et phycochromaceis. Fasciculus 21. Descriptiones systematice dispositae et index generalis fasciculorum 1–20.

Wolle, F. 1887. Fresh-water algae of the United States.

The Cactaceae of Southern Utah

ELZADA U. CLOVER

(WITH PLATES 15–19)

A field survey of the Cactaceae in a part of southern Utah yielded interesting material and new information regarding distribution of cacti. The work was sponsored by Mr. E. J. Marston of Colorado Springs, Colorado, who is interested in furthering a systematic and phytogeographic study of the family.

The author was accompanied and assisted by Miss Carol Davidson of Colorado Springs; and although the time (July 31 to August 15) was brief in which to cover so much territory, the results were gratifying. Many of the roads in the following counties were traversed: Grand, San Juan, Kane, Washington, Iron, Garfield, Wayne, and Emory.

This territory is drained chiefly by the Green and Colorado Rivers and their tributaries. The Virgin River has its origin in western Kane County and flows through Washington County. Most of southern Utah belongs to the Plateau province as defined by Powell. The extreme southwestern portion is included in the Great Basin.

This part of Utah holds a special interest for the botanist because it is within the northern limits of the Lower Sonoran desert zone, although theoretically most of it should be northern desert. The flora has not been well studied because of the scarcity of population and lack of roads. Thousands of square miles of southeastern Utah are entirely unsettled and a pack train with a competent guide who knew the country well enough to find waterholes would be necessary for thorough exploration.

Clay and sandstone of the Jurassic and Triassic cover the major part of counties studied. The exposed rocks range from whitish-pink to deep red sandstone, and light to chocolate shales with outcrops of limestone.

The cacti extend their ranges more slowly than many plants, because they grow slowly and have no special modifications insuring seed dissemination. Without question, the ranges of many species have been limited by physiographic features; some cacti are found on one side of a mountain range and not on the other, although conditions appear to be practically the same on both sides. Where such barriers exist, distribution follows water courses. The canyons and cuts in the vicinity of Fruita have a more southern flora than one would expect, since the upland here belongs to the piñon zone. The lower altitude may have some influence, but it is thought that the Lower Sonoran flora follows the valleys since migration over the high plateaus is impossible.

Altitude has a decided effect on vegetation, the lowlands having a growing season two to three times as long as that of the high plateaus. The precipitation in general is greater at higher altitudes, although St. George with an altitude of only 2880 feet has a greater rainfall than Loa with an altitude of 7000 feet. Navajo Mountain, judging by the vegetation, receives an annual rainfall exceeding 20 inches; while the surrounding country has a very meager rainfall, and little or no vegetation in places as a result.

Soil seems to be more of a limiting factor for some species than others. *Echinomastus Johnsonii* apparently needs calcareous soil. The *Echinocerei* also can be found on limestone ledges or on sand mixed with limestone without so much regard to altitude or moisture, but the caespitose form of *Pediocactus* and the western *Coryphanthae* are confined to the higher altitudes and show greater latitude in the matter of soil tolerance. The solitary form of *Pediocactus* grows at a lower altitude than the other but is found at its best under rather moist conditions, often close to streams or standing water. Several species of cacti in the vicinity of St. George have either abruptly reached the northern limit of their range or are limited by other factors than climatic. The lower altitude and correspondingly higher temperature in the extreme southwestern part of the state may account for the richness of the sub-tropical cactus flora.

It is possible that soil conditions may be at least partially responsible for northern limits of range. The Precambrian strata are exposed in this section and extend over the portions of Nevada, California and Arizona occupied by these same species. They are characterized by limestones which may have the same distribution as the characteristic plants of the region.

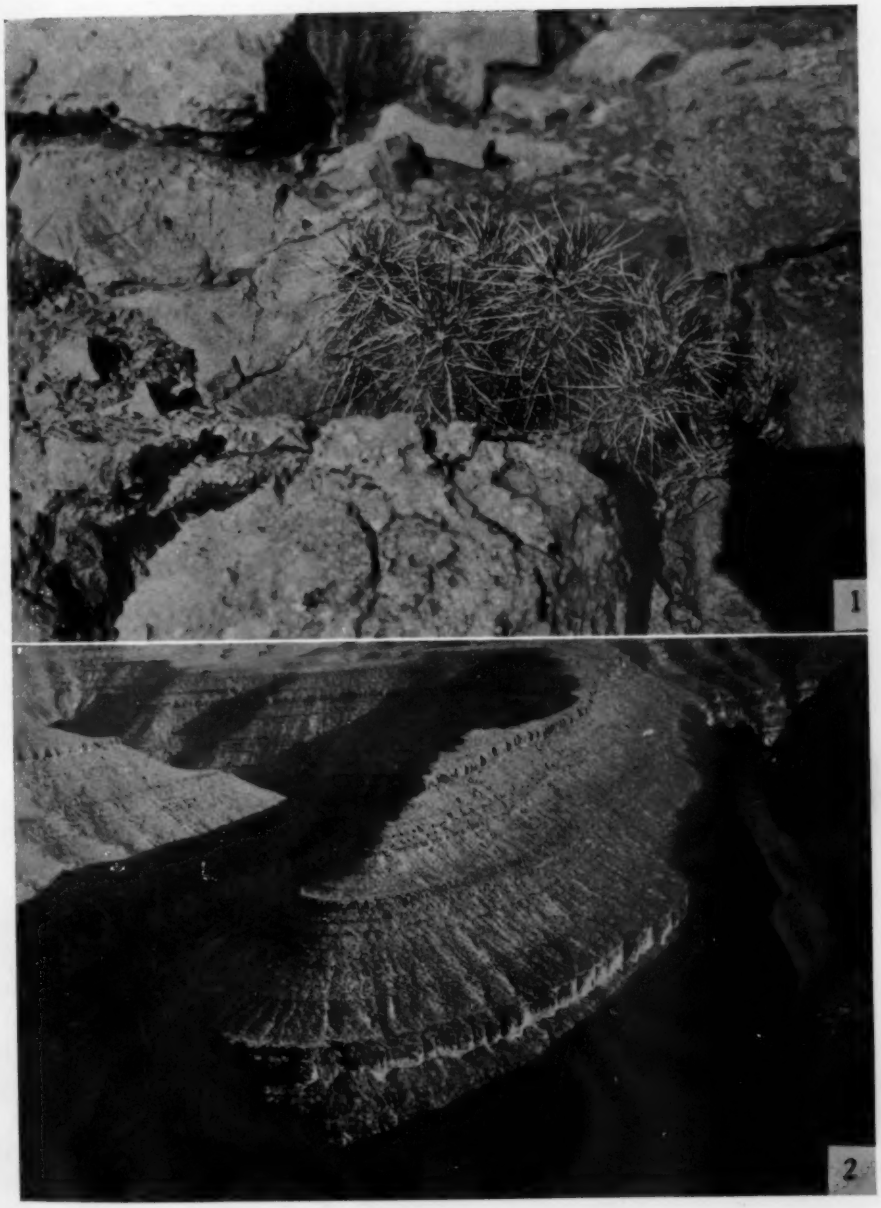
Catastrophes have played some part in retarding distribution. *Opuntia polyacantha* and *Sclerocactus Whipplei* can be found in fair abundance, north of Bluff, but the plants are mostly dead or dying probably from drought. An annual rainfall of three inches has been reported for Bluff. Farther east in the dust bowl region skeletons of numerous plants testify to the effect of changing conditions there. Flood waters in mountainous areas destroy species which may be migrating, and may on the contrary deposit plants or seeds which become established in a new territory.

It is interesting to note the variation within a species throughout a

Explanation of Plate 15

Fig. 1. *Echinocereus Engelmannii* reported to have white flowers. Growing on limestone near the San Juan River (fig. 2).

Fig. 2. The "Goosenecks," cut through shale and sandstone by the San Juan River, Mexican Hat, San Juan Co., Utah.



CLOVER: CACTACEAE

range of fifty to several hundred miles, particularly in a north and south direction. The change in form and character is often so gradual that it can scarcely be detected, but plants from the extremes of these ranges can often scarcely be recognized as belonging to the same species. Specific examples are *Opuntia fragilis* and *Opuntia polyacantha; Echinocereus Reichenbachii* and some of the opuntias growing farther east also vary greatly.

The family is generally thought of as young from the evolutionary standpoint in such aggressive genera as *Optunia*. There are, however, locally restricted types of no very obvious affinity that give the impression of being possibly ancient. Such a one is *Utahia Sileri*, which is very different from other cacti in the region and has a limited distribution. If this is the method of evolution, we are presented with the necessity of accounting for apparently continuous variation as the specific range is traversed, on the ground of successive cumulative changes in the same direction. Of course "place effect" may be of greater magnitude than seems likely. The seemingly continuous gradations afford magnificant material for genetic research bearing on the problem of climatic and habitat adaptation.

LIST OF SPECIES

OPUNTIA RAMOSISSIMA Engelm., Amer. Journ. Sci., Series 2, **14:** 339. Specimens collected at Beaver Dam Wash, Washington Co. by a citizen of St. George (1870). This is an odd species of the subgenus *Cylindropuntia*, with no close relatives. Reported hitherto from southern Nevada, western Arizona, southeastern California and northwestern Sonora.
HABITAT: Dry desert flats.

OPUNTIA WHIPPLEI Engelm. & Bigelow, Proc. Amer. Acad. **3:** 307. 1856. Kanab, and Johnson, Kane Co. (1883); Enterprise, St. George, Washington Co.; Santa Clara Valley, Iron Co. Reported elsewhere from northern New Mexico, Arizona and southwestern Colorado.
HABITAT: Sandy calcareous soil on south and west slopes, also on sandy flats, associated with Joshua trees, *Ferocactus acanthodes*, *Echinomastus Johnsonii* and *Echinocerous Engelmannii* at St. George, Washington Co.; on red sandstone in Kane Co.; on rocky slopes near Enterprise, Washington Co.

OPUNTIA ACANTHOCARPA Engelm. & Bigelow, Proc. Amer. Acad. **3:** 308. 1856. South of St. George, Washington Co. (1882). This species is probably most abundant in Arizona although it is found in California near the Nevada state line and the Colorado River; also common in Nevada.
HABITAT: Foothills or stony mesas, on limestone, sandstone and shale.

OPUNTIA ECHINOCARPA Engelm. & Bigelow, Proc. Amer. Acad. **3:** 305. 1856. St. George, Washington Co. (1886); Kanab, Kane Co., Beaver Dam

Mts.; widespread in southern California and found in southern Nevada, northwestern Arizona and Sonora.
HABITAT: On mesas and slopes, limestone outcrops, sandstone and shale.

OPUNTIA BIGELOVII Engelm., Proc. Amer. Acad. **3**: 307. 1856. South of St. George, Washington Co. (1890). This has previously been found in Nevada, Arizona, California, Lower California and Sonora.
HABITAT: In isolated colonies which are often miles apart; in sandy soil or in sand mixed with decomposed granite; in limestone outcrops usually on dry steep hillsides, south and west exposures.

OPUNTIA BASILARIS Engelm. & Bigelow, Proc. Amer. Acad. **3**: 298. 1856. South of St. George in Joshua forest, Washington Co. (1887); Beaver Dam Mts.; present in northern Sonora, western Arizona, southern California and Nevada.
HABITAT: Calcareous soils on dry hillside; reported as growing also on river flood plains.

OPUNTIA AUREA Baxter, Journ. Cac. Succ. Soc. **5**: (6). 1933. Between Kanab and Zion National Park, Kane Co. (1885) at an altitude of 6500 to 7000 ft.; reported also on both sides of the Arizona-Utah border near the Kaibab Indian Reservation; Cane Beds, Pipe Springs, between Zion Park and Carmel, Utah; west of the Kaibab Indian Reservation to the lower slope of the Sierras near Bishop, California. This is one of the Basilares recently described, differing from *O. basiliaris* by having joints in a chain instead of in a truly basilar form.
HABITAT: South of Zion National Park on a dry, steep, clay hillside, associated with *Juniperus*.

OPUNTIA BRACHYCLADA Griffiths, Proc. Biol. Soc. of Washington, **27**: 25, 1914. In the Dixie National Forest between Veyo and Enterprise, Washington Co. (1888). This species was not recognized by Britton and Rose but has been taken up by Baxter in his report on California cacti as a distinct species of the Basilares. He collected the plant in Pine Canyon, Sheep Creek Canyon, Dead Man's Gulch, and Mescal Canyon all within fifteen miles. It has also been reported from above Big Bear Lake in the San Bernardino Mts.
HABITAT: West slope in sandy, calcareous soil. Only two clumps were found, but they were very characteristic.

OPUNTIA PHAEACANTHA Engelm., in Gray, Mem. Amer. Acad. **4**: 52. 1849. LaSal, Grand Co.; Bluff, San Juan Co., Kanab, Kane Co. (1894), Gunlock, Washington Co., Torrey and Fruita, Wayne Co. This species is rather widespread, occurring in Arizona, California, New Mexico, Colorado, west Texas and northern Mexico.
HABITAT: Sandy plains, desert foothills and mesas, often associated with *O. polyacantha*.

OPUNTIA RUBRIFOLIA Engelm., ex Coulter, Contrib. Nat'l Herb. **3**: 424,

1896. Between Comb Wash and Mexican Hat, San Juan Co. (1876). The type specimen was collected at St. George. The specimen collected at Mexican Hat is somewhat smaller than the type but apparently belongs here. New stems produced in the greenhouse have the characteristic red color.
HABITAT: Dark red sandstone and granite fragments. L. A. Woodbury (unpub.) reports a collection of this species in Zion National Park, Utah, April 23, 1930.

OPUNTIA CHLOROTICA Engelm. & Bigelow, Proc. Amer. Acad. **3**: 291. 1856. Zion National Park, Washington Co., between Kanab and Johnson (1881), Kane Co. The distributiion is Sonora and New Mexico to Nevada, Utah, Arizona, California and Lower California.
HABITAT: On rocky hillsides and mountains usually below 4200 feet.

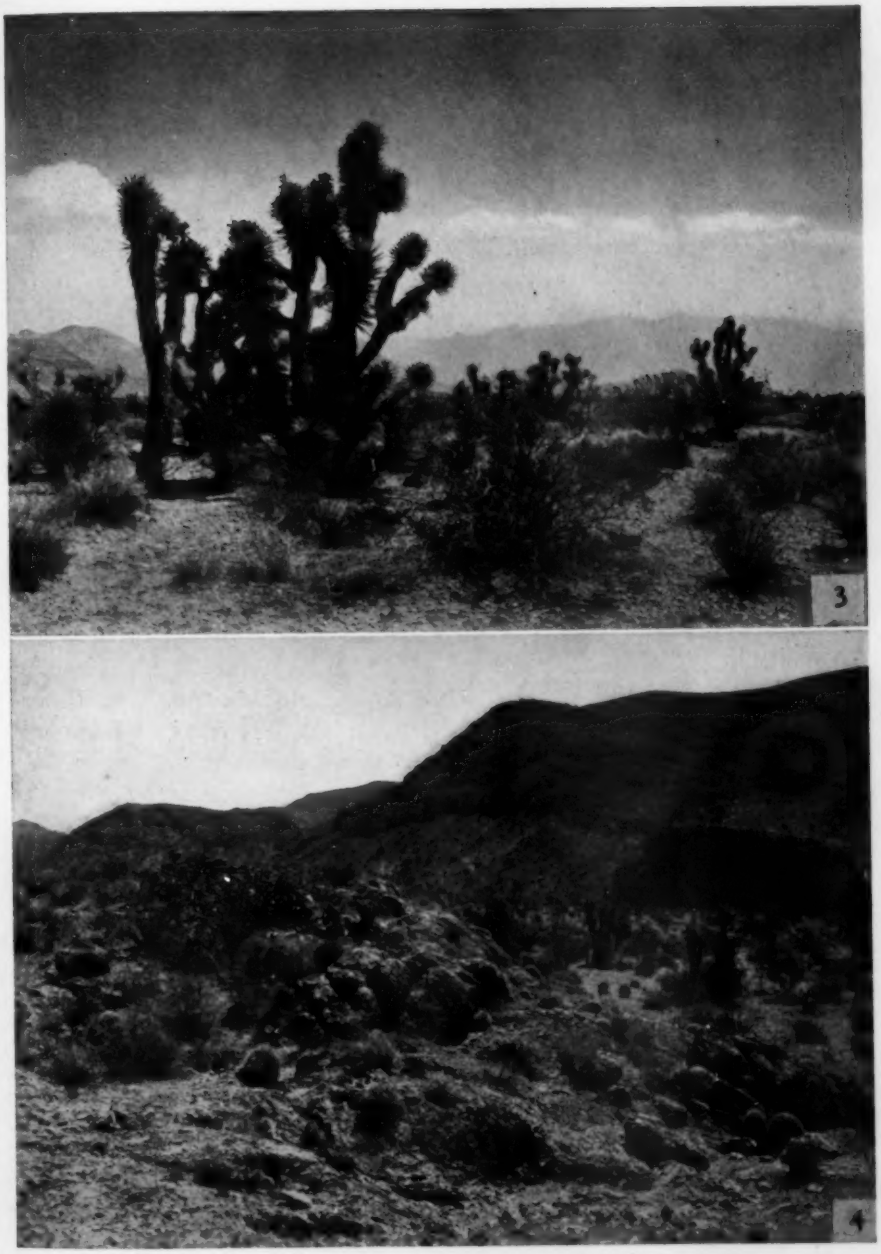
OPUNTIA FRAGILIS (Nutt.) Haworth, Suppl. Pl. Succ. **82.** 1819. Between Boulder and Torrey, Washington Co., Fruita, Wayne Co., Escalante, Washington Co., LaSal, Grand Co. (1873). This species has a wide geographic range and varies greatly in form under different conditions. It occurs in the Middle West from Wisconsin to central Kansas, and from northwest Texas to Arizona, Utah, Colorado, Oregon, Washington and British Columbia.
HABITAT: Often associated with *O. polyacantha* on rocky hillsides, frequently in shaded situations; in oak and yellow pine belts.

OPUNTIA POLYACANTHA Haworth, Suppl. Pl. Succ. **82.** 1819. LaSal, San Juan Co., Moab, Grand Co.; Blanding and Montecello, San Juan Co., Kanab, Kane Co.; Zion National Park, Washington Co.; St. George, Washington Co. (1872); Fruita, Wayne Co.; in grassland between Hanksville and Green River. A common species in several western states from Nebraska and North Dakota to northwestern Oklahoma and Texas, from Arizona north to Alberta. Arizona and Utah are apparently the western limit.
HABITAT: Sandy soil on desert plains, where it flourishes to the point of becoming a menace to ranchers; rocky hillsides often in juniper forests or associated with yucca. The flowers of this species not only vary from yellow to orange but are often magenta. This has caused some confusion, especially since Britton and Rose give the color of the flower as lemon yellow. The author has seen these plants in bloom on the Colorado plains with both yellow and magenta flowers on the same plant. An instance is known where scientific work was being carried on presumably with two species. The plant with magenta flowers was called *O. rhodantha* and the yellow flowered one, *O. polyacantha*.

Explanation of Plate 16

Fig. 3. Joshua Forest, southwest of St. George, Washington Co., Utah. A subtropical cactus flora extends over this area.

Fig. 4. *Ferocactus acanthodes* and *Echinocerus Engelmannii* are in the foreground; *Opuntia echinocarpa* and Joshua trees are in the background.



CLOVER: CACTACEAE

OPUNTIA RHODANTHA Schumann, La Semaine Hort. 1897. Zion National Park, Washington Co.; Boulder, Garfield Co. (1889); Torrey and Fruita, Wayne Co. This species is found in western Nebraska, Colorado and Utah. Helen Dixon (Bot. Gaz. **97**: 272–320) reported *O. xanthostemma* for the southern desert region in the vicinity of Torrey. It is probable that her specimen was *O. rhodantha* instead, since *O. xanthostemma* is a doubtful species.
HABITAT: Plains, canyons and mountain sides, associated with sage-brush and piñon; also with aspen and yellow pine.

OPUNTIA ERINACEA Engelm., Proc. Amer. Acad. **3**: 301. 1856. Montecello, San Juan Co.; Zion National Park, Washington Co.; St. George, Washington Co. (1895); Beaver Dam Mts.; Santa Clara Valley. Reported elsewhere from northwestern Arizona, southern Nevada, eastern California. The author has collected this species west of the Continental Divide in Colorado. It has been found frequently by Miss Carol Davidson who has collected in Colorado.
HABITAT: Apparently confined chiefly to the Lower Sonoran Zone. On sandy plains and on limestone hills and ledges; associated sometimes with *O. polyacantha* and with *Echinocerei*. It grows at a rather high altitude usually above 3500 feet.

OPUNTIA TENUISPINA Engelm. Proc. Amer. Acad. **3**: 294. 1856. Specimens apparently correctly identified as *O. tenuispina* have been obtained from Zion National Park. This species was collected first in Zion National Park by L. A. Woodbury in 1930.

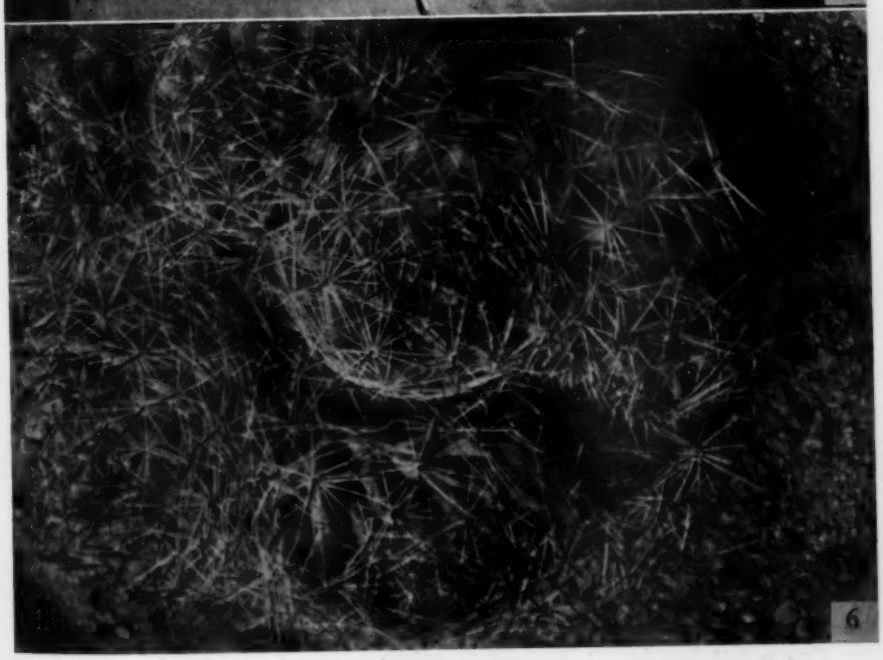
OPUNTIA STENOCHILA Engelm., Proc. Amer. Acad. **3**: 296. 1856. Hanksville, Wayne Co. (1896). Hitherto reported from western New Mexico and northeastern Arizona. It resembles the common species of the eastern Mississippi Valley but is a lighter green, and has a slightly longer areole than the many specimens observed in the Middle West.
HABITAT: Near the banks of the Dirty Devil River, sandy soil.

ECHINOCEREUS MOJAVENSIS (Engelm. and Bigelow) Britt. & Rose, Cact. **3**: 8. 1922. Zion National Park, Washington Co.; Between Zion and St. George (1897); Joshua forest south of St. George; Upper Santa Clara Valley. This species is fairly abundant in western Arizona, southeastern California, Nevada and southwestern Utah. It has also been reported from Sonora.
HABITAT: Limestone outcrops and sandy calcareous soil on hillsides, usually on south and west slopes. Associated in the vicinity of St. George with *E. Engelmannii*, *Opuntia basilaris*, *O. Bigelovii*, *Ferocactus acanthodes*, *Echinomastus Johnsonii* and *Phellosperma tetrancistra*, also with *Clistoyucca* (Joshua tree). Found in *Covillea* and *Artemesia* areas.

Explanation of Plate 17

Fig. 5. *Ferocactus acanthodes*, a young plant showing the characteristic twisting of spines and the absence of hooks.

Fig. 6. *Coryphantha Marstonii* found on "Hell's Backbone," Boulder, Garfield Co., Utah. Type.



CLOVER: CACTACEAE

ECHINOCEREUS TRIGLOCHIDIATUS Engelm., in Wislizenus, Mem. Tour North. Mex. **93.** 1848. LaSal, Grand Co. (1900). This cactus is found in western Texas, New Mexico, eastern Colorado and Utah. The author has seen specimens from the Uinta Mts., collected by E. H. Graham of the Carnegie Museum, Pittsburgh; L. A. Bradbury collected it on the Shewits Indian Reservation near St. George.
HABITAT: Limestone ledges in full light and sometimes under juniper trees partially shaded. Found also on flats in sandy calcareous loam.

ECHINOCEREUS OCTACANTHUS (Muhlenpfordt) Britt. & Rose, Cact. **2:** 13, 1922. LaSal National Forest, Grand Co. (1898), Comb Wash, near Mexican Hat, San Juan Co.; Fruita, Wayne Co.; Common west of the Continental Divide, Colorado; the Uinta Mts., Utah; northern Texas and New Mexico.
HABITAT: Limestone outcrops on ledges or hillsides. Abundant in Shavina Canyon, Montrose, Colorado. This species is unquestionably confused with *E. coccineus* which it closely resembles in form and habit. As far as the writer has observed from field studies in the western states *E. octacanthus* is much more abundant than *E. coccineus*, although, judging from the reports on distribution, the latter would seem to be.

ECHINOCEREUS COCCINEUS Engelm. in Wislizenus, Mem. Tour North. Mex. **94:** 1848. Zion National Park; between Zion and St. George, Washington Co. (1884). This species has been found in the Uinta Mts. in western Colorado; and is reported from New Mexico and Arizona.
HABITAT: Calcareous soil, usually on ledges or hillsides; near Zion associated with *E. Engelmannii* and occasionally with *E. mojavensis*.

ECHINOCEREUS ENGELMANNII (Parry) Rumpler in Förster, Handb. Cact. ed. **2:** 805. 1885. Mexican Hat, San Juan Co. (1878); Zion National Park; between Zion and St. George, (1880); Joshua forest south of St. George; Beaver Dam Wash; and Gunlock and Veyo, Washington Co. Distributed elsewhere in California, Arizona, Nevada, Lower California, and Sonora.
HABITAT: Limestone ledges, rocky calcareous hillsides. This species seems to be able to thrive under less favorable conditions than other Utah Echinocerei, i.e., in more extreme desert conditions, and in poorer soil. Abundant in Joshua forest, often associated with *Covillea tridentata*. A specimen from Mexican Hat is said by Mrs. W. E. Nevills to have white flowers.

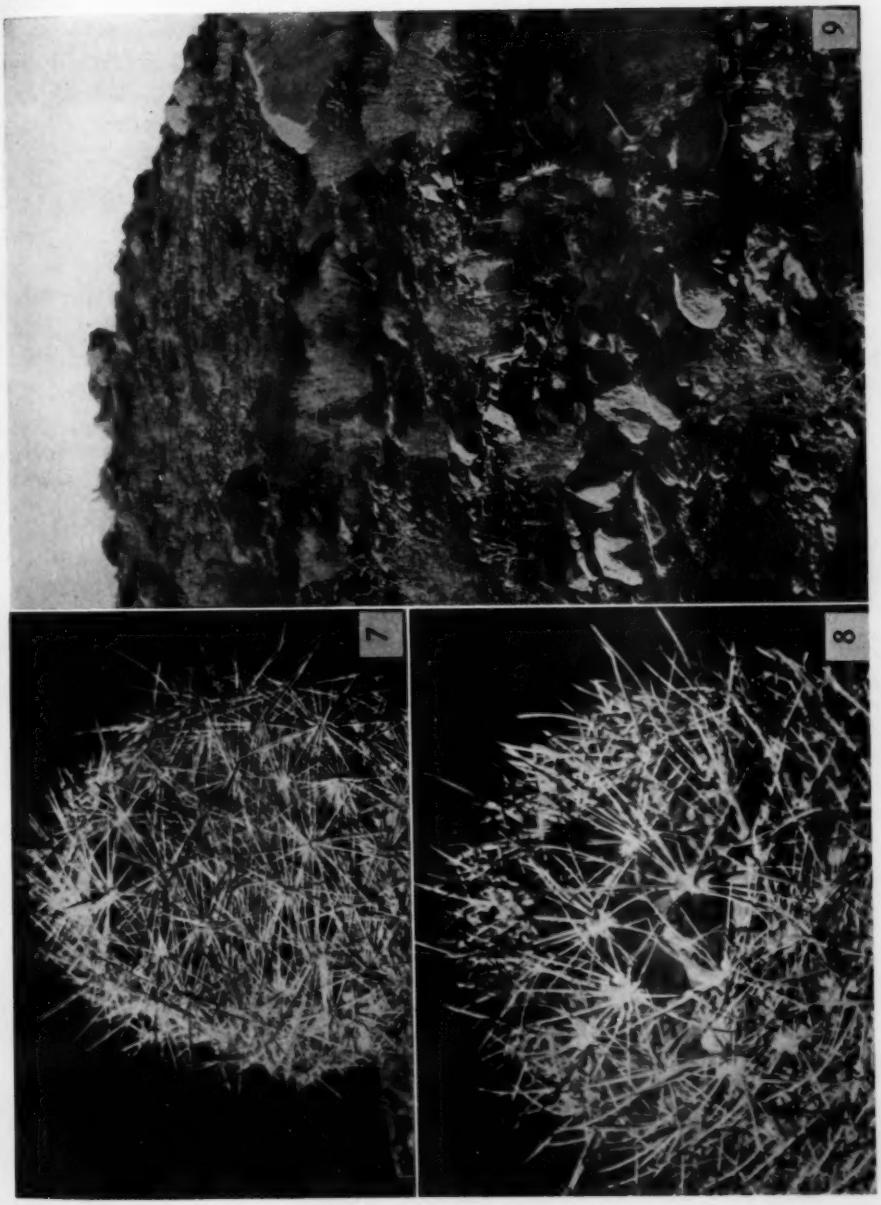
ECHINOCEREUS FENDLER (Engelm.) Rumpler in Förster, Handb. Cact. ed. **2:** 801. 1885. Utah-Arizona border, Monument National Park (1879). This species has been collected in Texas, New Mexico, Nevada, Utah, Arizona,

Explanation of Plate 18

Fig. 7. *Coryphantha* sp. nov. found between Veyo and Gunlock, Washington Co., Utah.

Fig. 8. *Utahia Sileri*. Near the Arizona-Utah border, Fredonia, Arizona.

Fig. 9. *Echinocereus octacanthus* on a limestone hillside near Zion, Utah.



CLOVER: CACTACEAE

Colorado (a single collection made by D. M. Andrews between Colorado Springs and Florence, Colorado), northern Sonora and Chihuahua.
HABITAT: Desert areas on hills and mesas, often among broken granite and limestone. Abundant in the Red Knolls Amphitheatre north of Safford, Arizona. The long-spined form was found on the Utah-Arizona border.

FEROCACTUS ACANTHODES (Lemaire) Britt. & Rose, Cact. **3**: 129. 1922. South of St. George, Washington Co. (1893). Previously reported from southeastern California, northern Lower California, and southern Nevada. *Ferocactus Lecontei* is reported by Britton and Rose and by Tidestrom as occurring in southwestern Utah. The author is of the opinion that their plants were *Ferocactus acanthodes*. In response to an inquiry regarding this problem E. M. Baxter, author of a recent book on California cacti writes (with permission to quote) the following with which the author agrees:

> I received your letter with the two photographs. The plant shown is the same *Ferocactus* that I illustrated in my book as *F. Lecontei*. I have never been as far as Utah, but had my first plants from Nevada. In going over the literature dealing with *F. Lecontei* and the plants you have photographed I have come to these conclusions:
>
> 1. There is no *Ferocactus Lecontei*. 2. My plants and your pictures are *Ferocactus acanthodes*. 3. The descriptions of *Ferocactus Lecontei* are of *F. Wislizeni* and the name should be listed as a synonym of the latter.
>
> I have arrived at these conclusions after seeing specimens from all territories, having the plants in flower, and comparing written descriptions.

It is possible that *Ferocactus Wislizeni* grows in this vicinity although all specimens examined were definitely *F. acanthodes*.
HABITAT: Dry, limestone hillsides in Joshua forest, and assciated with *Opuntia acanthocarpa*, *Echinomastus Johnsonii*, *Artemesia* and *Covillea tridentata*.

ECHINOMASTUS JOHNSONII (Britt. & Rose) Hester, Cact. and Succ. Journ. **5**: no. 7. 1934. South of St. George, Washington Co. (1892). This plant is found elsewhere in northwestern Arizona, and in southern Nevada.
HABITAT: Similar to that of *Ferocactus acanthodes* in the vicinity of St. George. It is found on calcareous soil usually on hillsides or mesas.

SCLEROCACTUS WHIPPLEI (Engelm. & Bigelow) Britt. & Rose, Cact. **3**: 213. 1922. Between Montecello and Moab, San Juan Co. (1871). This species has a rather limited range, occurring in western Colorado, southeastern Utah, and northern Arizona.
HABITAT: In rather high altitudes, often on clay hillsides and mesas; found in abundance in red sandstone on cliffs near Moab associated with *Artemesia* and some cedar; unhealthy and dying plants on limestone flats near the Arches National Monument, Grand Co.; dying plants in desolate areas north of Bluff, San Juan Co., in red sandstone.

SCLEROCACTUS POLYANCISTRUS (Engelm. & Bigelow) Britt. & Rose, Cact. **3**: 213–214. 1922. Mexican Hat, San Juan Co. (1877). Torrey and Fruita,

Wayne Co. (1902). Distributed in southern California, northwestern Arizona, Nevada and Utah.

HABITAT: Rather high altitude on red sandstone and clay. At Mexican Hat a few large plants were found growing on almost completely barren, deep red hills.

The specimens found at Fruita were of unusual interest because some bore magenta flowers and others growing within a few feet were yellow. Engelmann in his original description states that the flowers are yellow. Schumann also describes them as yellow, while Coulter describes them as red or yellow. Britton and Rose give the color as magenta as does E. M. Baxter. The plants at Mexican Hat have long red and white spines, those at Fruita and Torrey are all white or brown and white.

PEDIOCACTUS SIMPSONII (Engelm.) Britt. & Rose, in Britt. and Brown, Illus. Fl. ed. 2. **2**: 570. 1913. Between Boulder and Torrey, Wayne Co. (1910). This cactus is found in western Kansas, Colorado, New Mexico, Utah, Nevada, Wyoming, Washington, Oregon, Idaho and Montana.

The plant is variable and it is possible that there are at least two distinct species. One, abundant on Monarch Pass, Colorado, at an altitude of over nine thousand feet is often caespitose, having as many as twenty-five or thirty heads in one clump; these rather small and densely covered with white spines, sometimes tipped with brown, some having brown spines. The other, grows in valleys, often near a stream, sometimes in damp locations, a solitary plant which is usually flattened somewhat and much greater in diameter at maturity than the high mountain form. This one is found near Boulder, Utah; Gunnison, Colorado; and in Estes Park, Colorado near the Big Thompson River. Both forms were brought to the Botanical Gardens, University of Michigan a year ago. The solitary form (Accession No. 16576) is thriving while the other form (16576A) is either dead or dying although most cacti do well here. The high mountain form has probably been influenced by the low altitude (750 feet).

UTAHIA SILERI (Engelm.) Britt. & Rose, Cact. **3**: 215. 1922. About three miles west of Fredonia, Arizona, near the Utah border (1904). Distribution of this species is given by Britton and Rose as Cottonwood Springs and Pipe Springs, southern Utah. (However, Pipe Springs is in Arizona.) It is fortunate that the plant grows in an isolated place because it undoubtedly has a limited distribution and does not grow abundantly. E. H. Graham questionably refers a poorly preserved specimen from the Pariette Desert to this genus.

HABITAT: In red sandstone strewn with selenite; associated with *Artemesia in* very barren and unpromising surroundings.

PHELLOSPERMA TETRANCISTRA (Engelm.) Britt. & Rose, Cact. **4**: 60. 1923. South of St. George, Washington Co. (1891). The range of this species is western Arizona, southeastern California, southern Nevada and southwestern Utah.

HABITAT: The plant is apparently extremely rare in Utah and difficult to find because its white spines blend so well with the light colored soil and limestone fragments among which it grows in the Joshua forest.

CORYPHANTHA DESERTI (Engelm.) Britt. & Rose, Cact. **3**: 46. 1923. St. George, Washington Co. (1906). The range of this species has been extended the last few years; it is now known from southern California, southern Nevada, southern Utah and southwestern Colorado.
HABITAT: Desert areas in sandstone, among rocks, and on hillsides.

CORYPHANTHA AGGREGATA (Engelm.) Britt. & Rose, Cact. **4**: 47–48. 1923. Blanding, San Juan Co. (1875). Distributed in western New Mexico, southeastern Arizona and along the Colorado River, southwestern Colorado, southern Utah and Sonora.
HABITAT: Found at Blanding in piñon and cedar area, limestone hills.

CORYPHANTHA CHLORANTHA (Engelm.) Britt. & Rose, Cact. **4**: 43. 1923. East of St. George, Washington Co. (1907); known also from western Arizona, central Nevada and reported from southern California.
HABITAT: Hillsides, in red sandstone and often among rocks.

CORYPHANTHA ECHINUS (Engelm.) Britt. & Rose, Cact. **4**: 42. 1923. LaSal National Forest, San Juan Co. (1874). The range of this plant is recorded far south of Utah, and it is surprising to find it so far north of its known habitat. The species has apparently been reported only from western Texas. Since the part of New Mexico, Utah and Arizona lying between these two regions are difficult to botanize thoroughly, it is possible that the plant has a wider distribution than we think. Two caespitose specimens were found.
HABITAT: Limestone hills, at LaSal, associated with *Opuntia fragilis*, *O. Phaeacantha*, *O. polyacantha*, on a hill sparsely covered with pines.

CORYPHANTHA ARIZONICA (Engelm.) Britt. & Rose, Cact. **4**: 45–46. 1923. This species was not collected but was seen growing in gardens in the vicinity of St. George and was reported to have been collected locally. It has been found in northern Arizona, at Pipe Springs and near Cima and Goffs, California. Specimens closely resembling it were found by Miss Carol Davidson and the author in southwestern Colorado.
HABITAT: On hills, growing at a rather high elevation.

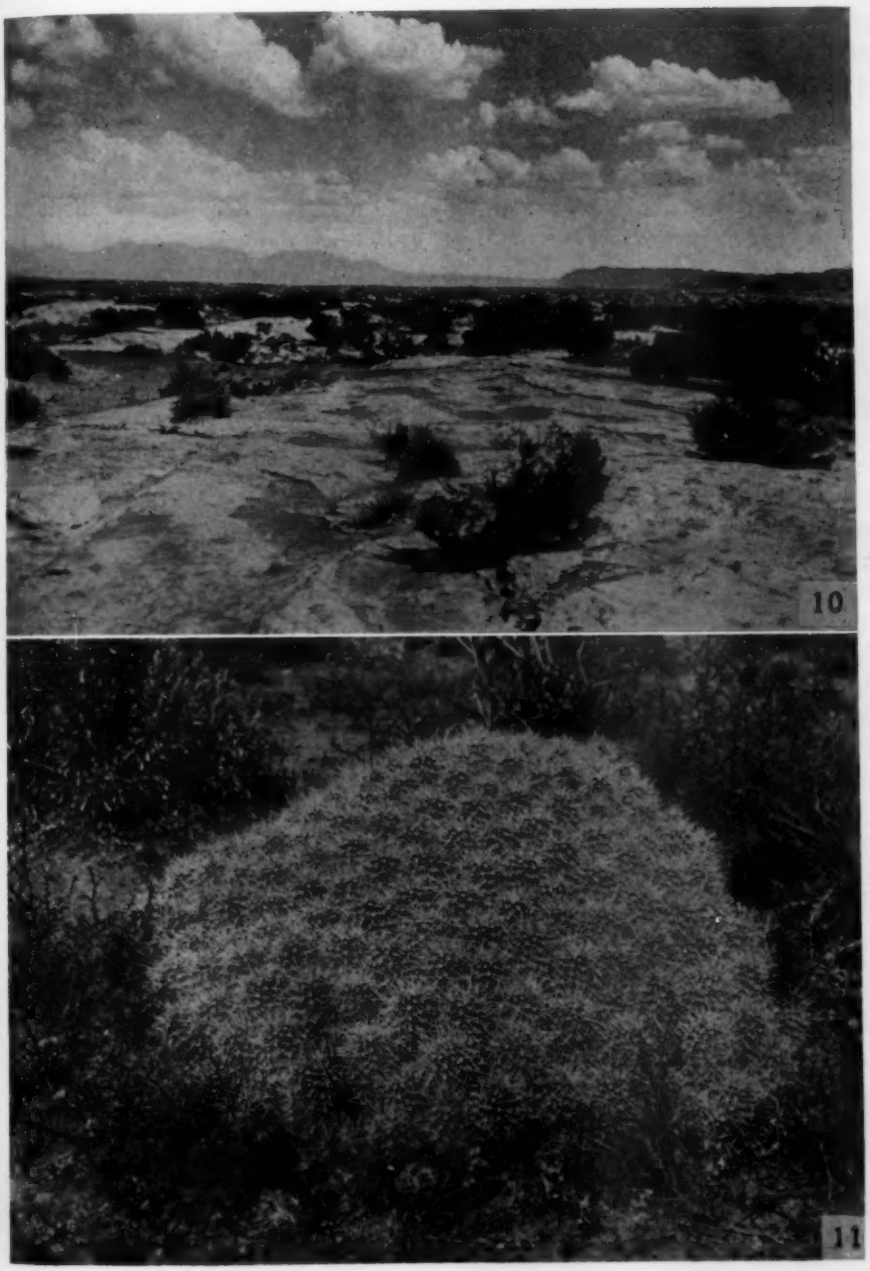
Coryphantha sp. nov.

Between Veyo and Gunlock, Washington Co. (1908). One healthy, and two dying specimens were found on a hillside in red sandstone strewn with granite fragments, associated with *Artemesia* and stunted *Covillea tridentata*. The

Explanation of Plate 19

Fig. 10. Limestone outcrop in sandstone north of Moab, Grand Co., Utah. *Juniperus utahensis* and *Artemesia* are dominant. Unhealthy plants and skeletons of *Sclerocactus Whipplei* and *Opuntia polyacantha* are found here.

Fig. 11. *Echinocereus octacanthus* at the base of cliffs between Montecello and Moab.



CLOVER: CACTACEAE

plant in some ways fits the description of *C. deserti*. The spines, however, are coarse and have a decidedly purplish cast, becoming black at the tip; radial spines never more than fifteen, centrals four; while *C. deserti*, according to the original description has a total of from twenty-five to thirty. Only dried flowers were available, and they appear to be yellow. The fruit is rather large, greenish purple and has a taste not unlike that of a ripe paw-paw (*Asimina*). Because of the meagre amount of material the author does not feel justified in naming this plant even as a new form until it is seen in flower.

Coryphantha Marstoni sp. nov. Caespitosa, caulibus 4.5–6.5 cm. crassis; depresso-globosa; tuberculis sub-prismaticis, summis floriferis tomentosis sulcatis; junioribus dense lanatis; areolis 1.5 mm. latis, rotundis; spinis lateralibus radiatis, superioribus 4–5, setaceis rectis, albidis, inferioribus 9–12 radiantibus, rigidis, paullo recurvis, vel translucentibus pallide luteisque vel fuscis; 10–12 mm. longioribus, centralibus 2 vel 3, fuscis, apice nigris, inferiore (ex areolae centro) subulato, porrecto, 8–10 mm. longo; superioribus 12–15 mm. longis, rectis, obliquiter radiantibus; omnibus spinis basi bulbosis; floribus parvis, in plantae apice, 2 cm. longis, luteis, stigmatis lobis 5; filamentis numerosis; antheris luteis, fructibus ignotis. Utah. Specimen typicum (1909) vivum ex loco "Boulder" dicto conservatum est in Horto Botanico Universitatis Michiganensis.

Plant caespitose, forming a low flat clump with a stout tap root 2.5–3 feet long; stems crowded so that they are misshapen, depressed-globose, 4.5–6.5 cm. in diameter; tubercles sub-prismatic, about 1 cm. long, 4–5 mm. in diameter at base, very slightly less at tip; groove not extending to the base in all the older tubercles, lower end filled with whitish wool; aeroles circular, younger ones white-wooly; radial spines of two kinds, a tuft in upper end of areole, white, sometimes brown tipped, almost hair-like, somewhat shorter than other radials, these 9–12, rigid, acicular, uneven, the longest 10–12 mm. long, slender, horn-colored to light brown with darker tips, becoming grayish with age, radiating, occasionally slightly recurved, centrals usually 3, one in the center of the areole, subulate, porrect, with a swollen base, usually less than 1 cm. long, stouter than the other spines, red-brown to almost black at the tips; 1 or 2 upper centrals swollen at the base, similar in color to first central, rigid, acicular, ascending, pointing slightly outward, 12 to 15 mm. long; spines interlocking, forming rather a dense covering; flowers formed at base of tubercles at the apex, about 2 cm. long, yellow; style extending far beyond the stamens, stigma lobes 5; flower described from a dried specimen.

Distribution: Known only from the type locality, "Hell's Backbone," a mountain ridge near Boulder, Garfield, Co., Utah (1909). Papers from the Department of Botany and the Botanical Gardens, University of Michigan, no. 645.

UNIVERSITY OF MICHIGAN,
ANN ARBOR,
BOTANICAL GARDENS AND ARBORITUM

Response of sorghum to high and low soil moisture*

V. Panduranga Rao
(with two figures)

The grain sorghums are prominent among cereals of semiarid regions throughout the world. So far studies on sorghums have been largely confined to their morphology, genetics, and taxonomy. Only a small fraction of the voluminous literature on crop production is devoted to the highly important subject of roots and absorptive processes. That roots are the "least known, least understood, and least appreciated part of the plant" is particularly true of sorghums.

In India, sorghum is grown in a semiarid region characterized by low and irregularly distributed rainfall. Normally most of the rains fall as heavy downpours of as much as three to four inches in one day. During the last 30 years at Bellary, South India, dry cycles have occurred at intervals of four to five years with departures of six to eight inches below the 20-inch norm. Sorghum is the only grain crop that can be grown successfully under these conditions. It is also grown as a garden crop under irrigation. Hence, there is an urgent need for studying the response of this crop to widely different soil moisture content. There is little information on the subject of the response of roots of grain crops to wet and dry soils (Weaver and Clements, 1938).

Material and methods

Sorghum cernuum Host, was the species used in this experiment. Screened, fertile loess soil having a wilting coefficient of about 13 per cent was secured. It was divided into two lots which were adjusted to uniform moisture contents of 33 per cent (wet soil) and 14.8 per cent (dry soil), respectively.

Eight cylindrical galvanized iron containers 75 cm. deep and 28 cm. in diameter were used. A circular hole 6.5 cm. in diameter was cut in the middle of the side of each cylinder. These holes were corked while each of the two lots of soil was tamped uniformly into four containers. Lids were sealed on the completely filled containers with water-proof adhesive tape. Then the cans, each containing about 110 pounds of soil, were horizontally embedded in soil so that only the corks remained uncovered.

After removing the corks, three seeds were planted in each hole, and a thin layer of sand was added to reduce evaporation from the opening. The soil on the greenhouse bench between the containers was also planted to sorghum in order to provide conditions of competition for light similar

* Contribution from the Department of Botany, University of Nebraska, No. 106.

to those encountered in the field. Light watering until the seedlings were four days old permitted germination and establishment in the dry soil. At this time, the plants were thinned to one per container.

During the experiment, the average temperature of the soil in which the plants were rooted was 56° F. and the air temperature varied between 65° and 75° F. The short light period of the winter days was extended until 10:00 p.m. by the use of two 150-watt electric lights mounted in 15-inch, white, enameled reflectors placed 3 feet above the containers. These were also used on cloudy days. The intensity of the light thus provided at 7:00 p.m. was 38 foot candles as compared with 3,000 foot candles at midday. Average daily evaporation from Livingston's black spherical atmometers was 11.6 cc., and relative humidity ranged from 55 to 60 per cent.

At the end of 42 days, the walls of the containers were cut open and the root systems washed free of soil. The volume of the roots was obtained by displacement of water in a graduated cylinder after they had been pressed between paper towels to remove surface water. The root systems were then floated out in deep pans of water in approximately the position occupied in the phytometer. Calculation of the total area of the root system selected as average was based on the total number and length of roots and the average diameters, as measured with the compound microscope and micrometer scale. Root hairs were thus excluded. This method was developed by Weaver *et al* (1924). The typical root system selected was also drawn to scale on cross-ruled paper while it was floating in its natural position over black paper ruled in square centimeters. The areas of aboveground parts were measured by first making prints on solio paper of the flattened leaves and stems and then using a planimeter. Finally, roots and tops were weighed after drying them at 90° F. for 24 hours.

RESULTS

Plants Grown in Moist Soil

The plants grown in moist soil, as measured to the tip of the youngest leaf, were 25.9 cm. tall and had stems 15 cm. long. The eight leaves had a surface area—upper and lower combined—of 299.7 sq. cm. (table 1). The ratio of shoot area to root area (excluding root hairs) was 1.95:1. The dry weight ratio, similarly, was 2:1. There were present 10 primary roots (fig. 1) which ranged from 8.6 to 42.0 cm. long and had a combined length of 265.2 cm. They were white and very turgid. Their diameters were between .25 and 1.0 mm. and averaged .725 mm.

The area of the primary roots (47.35 sq. cm.) constituted 30.9 per cent of the area of the entire root system. Arising from the primaries were

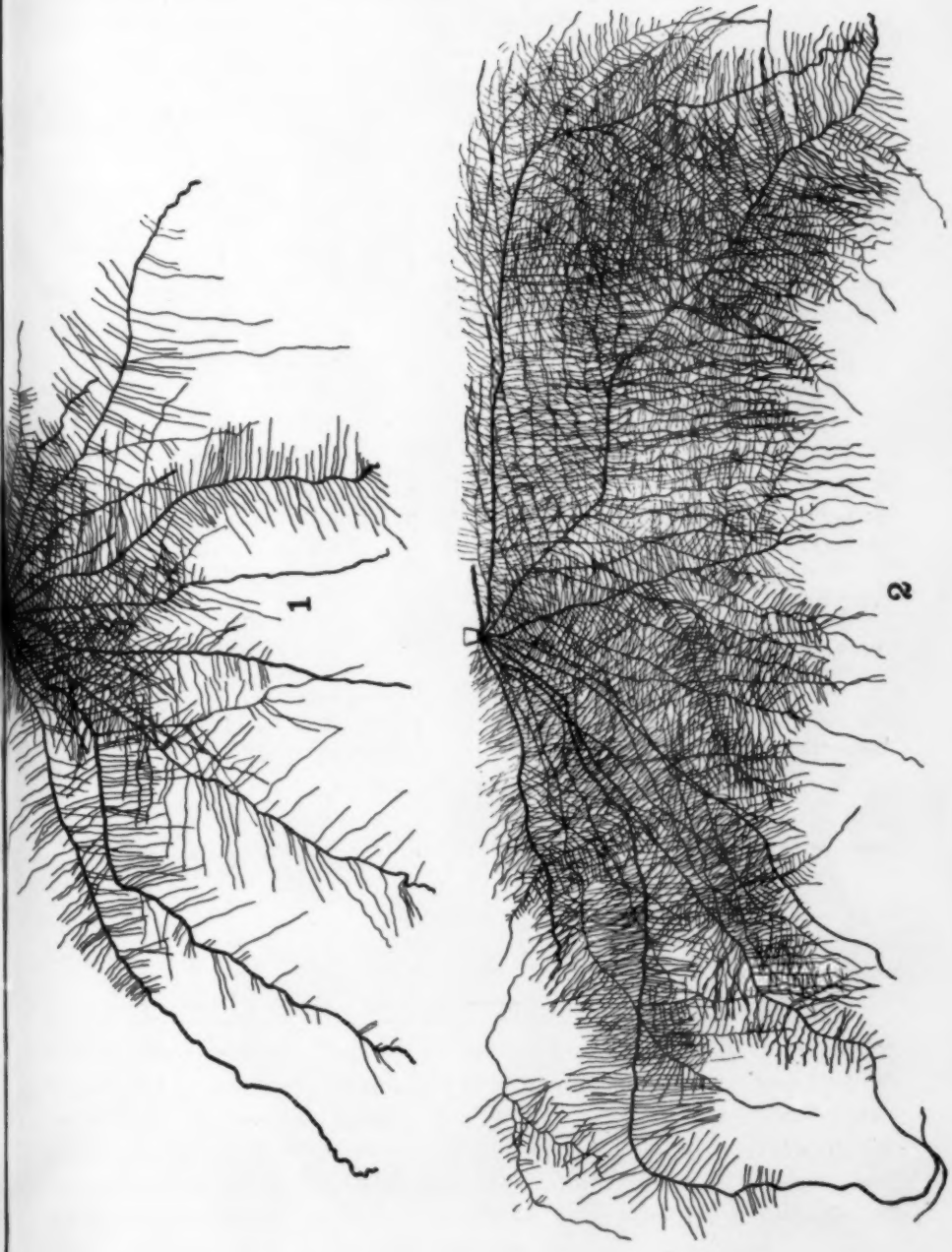


Fig. 1. Root habits of sorghum plants. Plants grown in (1) moist soil, and (2) dry soil, $\times\frac{1}{4}$.

758 short, white secondaries with a total length of 1,178.6 cm. and an area of 90.7 sq. cm. or 59.3 per cent of the total area. Roots of the third and fourth order provided 9.1 and .7 per cent, respectively, of the total area (153 sq. cm.) of the root system.

TABLE 1

Response of 42-day-old sorghum plants to high and low water content

CRITERIA	MOIST SOIL 33 PER CENT MOISTURE	DRY SOIL 14.8 PER CENT MOISTURE
Height of plant, cm.	25.9	21.0
Number of leaves	8	8
Photosynthetic area of tops, sq. cm.	299.67	222.34
Dry weight of tops, gram	0.317	0.252
Dry weight of roots, gram	0.153	0.246
Volume of roots, cc.	1.25	1.84
Number of primary roots	10	8
Number of secondary roots	758	1,007
Number of tertiary roots	470	1,952
Number of quaternary roots	101	354
Total number of roots	1,339	3,321
Length of primary roots, cm.	265.2	328.0
Length of secondary roots, cm.	1,178.6	3,017.9
Length of tertiary roots, cm.	415.8	2,649.5
Length of quaternary roots, cm.	51.0	177.0
Total length of root system, cm.	1,910.6	6,172.4
Absorbing area of primary roots, sq. cm.	47.35	57.40
Absorbing area of secondary roots, sq. cm.	90.70	265.60
Absorbing area of tertiary roots, sq. cm.	13.85	116.60
Absorbing area of quaternary roots, sq. cm.	1.13	3.90
Total absorbing area of roots, sq. cm.	153.03	443.50
Number of root hairs per unit length	33.0	83.4
Average length of root hairs, μ	229	136

The root hairs constituted by far the best absorptive agency of the plant. It was practically impossible to measure their total area because of their minuteness and abundance. However, microscopic determinations of their length and general distribution were made at different levels of the root system. The average number of root hairs per unit length (700μ) at fifty different levels was 33, with a maximum (in any unit length) of 41 and a minimum of 26. Only those root hairs visible on either side of the root when viewed through the microscope were counted. The average length of root hairs, determined from 500 readings at different levels in

all roots, was 229μ, the distribution in length varying from 525μ to 105μ.

The average volume of the root systems of four plants was 1.25 cc., the average dry weight .153 grams.

Plants Grown in Dry Soil

The plants grown in soil with approximately 1.8 per cent available moisture had eight leaves when 42 days old. They were 21 cm. tall and had stems 12.5 cm. long. The surface area of the shoot was 222.34 sq. cm., that of the root system 99 per cent greater. The average dry weight of tops was .252 gm. (table 1). The ratio of dry weight of tops to that of roots was 1.02:1.

The eight primary roots ranged in length from 2.5 to 130.7 cm. and had a combined length of 328 cm. The longest one consisted of a main root and six branches from its tip. These eight roots varied in diameter from .25 to 1.0 mm., the average being .5 mm. They were light brownish yellow in color. The area of the primary roots (57.4 sq. cm.) was 12.9 per cent of that of the root system.

There were 1,007 secondary roots with a total length of 3,017.9 cm. They were discolored like the primaries. Their area of 265.6 sq. cm. was 59.9 per cent of that of the root system. The 1,952 tertiary roots had a combined length of 2,649.5 cm. and an area of 116.6 sq. cm. This was 26.3 per cent of the total area and with the area of the secondaries composed 86.2 per cent of the total. The 3.9 sq. cm. area of the quaternary roots was distributed among 354 roots with a total length of 177 cm. This was .9 per cent of the whole 443.5 sq. cm. area of the root system.

The average number of root hairs per unit length of 700μ taken at fifty different levels was 83.4, and ranged from 68 to 118; their average length, as obtained from 500 measurements at different levels in all roots, was 136μ, the length varying from 70 to 287μ.

Average dry weight and volume of the root systems were .246 gm. and 1.84 cc., respectively.

DISCUSSION

Comparison of the foregoing data shows that low soil moisture content inhibited the growth of the shoot of sorghum while increasing the number and length of all orders of roots (except number of primaries). The primary roots were 1.24 times longer, secondaries 2.57 times, the tertiaries 6.37 times, and roots of the fourth order 3.47 times longer than those of moist soil. There were 1.33 times more secondaries, 4.15 times more tertiaries, and roots of the fourth order were 3.5 times more numerous. Stated conversely, moist soil favored the growth of tops and primary roots but

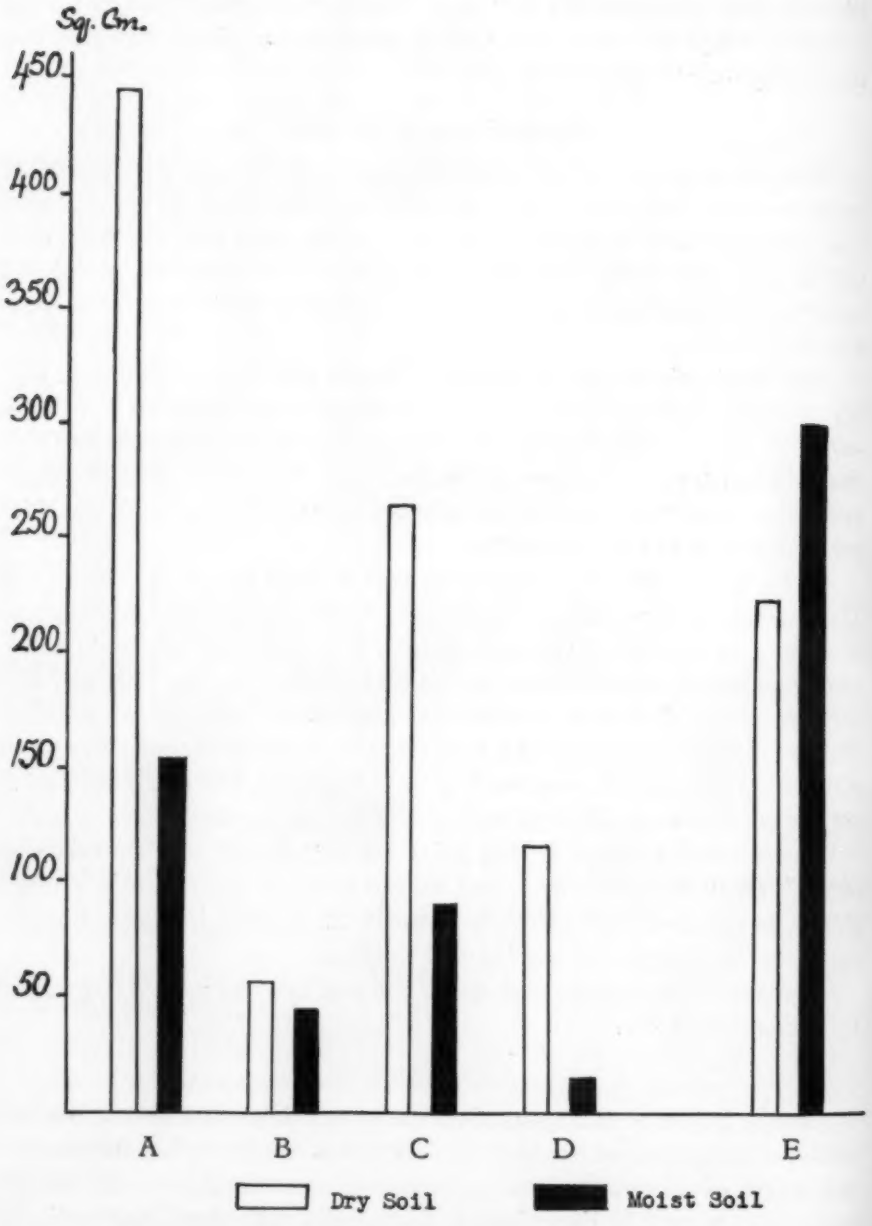


Fig. 2. Graph showing the relationship between: A, the area of the entire root system; B, the area of the primary roots; C, the area of the secondary roots; D, the area of the tertiary roots; and E, the photosynthetic and transpiring areas of *Sorghum* plants grown in dry and moist soil.

checked that of secondary, tertiary, and quaternary roots. The total length of the roots in dry soil (6,172.4 cm.) was 3.23 times as great as in plants grown in moist soil, and the root area in the former was 2.9 times that in the latter. In dry soil, root hairs were more numerous (83.4 per unit of length) and shorter (136μ) than in moist soil where the number was 33 and the length 229μ.

It is noteworthy that the dry soil dwarfed the shoot while accentuating root development (fig. 2). This tends toward an equilibrium between absorption of water and its loss in transpiration. In a similar study but using a more mesic species, Weaver and Clements (1938) found that "Corn grown for 5 weeks in a moist, rich, loess soil (available water content 19 per cent) had a total root area which was 1.2 times greater than that of the transpiring surface of stems and leaves. Similar corn grown with an available water content of only 9 per cent had a root area 2.1 times greater than that of tops . . . . Thus, a low water content, within certain limits, stimulates increased root development" of maize. Most of the increased absorbing area was furnished by "an excellent development of secondary and tertiary branches."

In this experiment, the root area of sorghum in moist soil was much less than the photosynthetic area, but in dry soil it was double the photosynthetic area. The primary roots in the dry soil were thinner and longer and constituted only 13 per cent of the total root area, whereas those in the moist soil were thicker and shorter and composed 31 per cent of the area of the root system. In moist soil the primaries and secondaries dominated, but in dry soil the secondary and tertiary roots provided the largest area. The capacity of the plant to elaborate its root system and at the same time to meet the stress of drought by limiting the development of its shoot is especially noteworthy (fig. 2).

SUMMARY

Sorghum plants were grown for 42 days in soils with 33.0 and 14.8 per cent moisture of which only about 20 and 1.8 per cent, respectively, were available for growth, *i.e.*, above the hygroscopic coefficient.

Plants grown in moist soil were one-fourth taller and heavier and had one-third more photosynthetic area than those grown in dry soil. In moist soil the dried tops were twice as heavy as the roots but in dry soil the weight of tops and roots was the same. Haasis (1921), and Crist and Stout (1929) also found that the dry weight ratio of shoot to root is proportional to available soil moisture. The plants grown in dry soil had more and longer roots and nearly three times the area of those in moist soil.

Under both treatments, well developed secondary roots were produced. The moist soil proved more favorable to the development of primary roots, but the tertiaries were better in dry soil. Volumes of root systems in the moist and dry soils averaged 1.25 cc. and 1.84 cc., respectively. In the latter, root hairs were more abundant but shorter. Dryness of soil stimulated root growth considerably and inhibited the growth of above-ground parts.

The author wishes to express his sincere gratitude to Dr. J. E. Weaver for suggesting the problem and for interest shown throughout the work.

Literature cited

Crist, J. W., and G. J. Stout. 1929. Relation between top and root size in herbaceous plants. Plant Physiology **4**: 63–85.

Haasis, F. W. 1921. Relations between soil type and root form of western yellow pine seedlings. Ecology **2**: 292–303.

Weaver, J. E., J. Kramer, and M. Reed. 1924. Development of root and shoot of winter wheat under field environment. Ecology **5**: 26–50.

————., **and F. E. Clements.** 1938. Plant ecology. 2nd ed. p. 296 New York: McGraw-Hill Book Co.

INDEX TO AMERICAN BOTANICAL LITERATURE
1935–1937

The aim of this Index is to include all current botanical literature written by American, published in America, or based upon American material; the word America being used in the broadest sense.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of three cents for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the index may be addressed to the Treasurer of the Torrey Club.

Atwood, S. The nature of the last premeiotic mitosis and its relation to meiosis in *Gaillardia*. La Cellule **46**: 391–409. *f. 1–54*. 1937.

Azeredo-Penna, L. de. O vento e a vegetacao. Rodriguesia **2**[9]: 97–99. *f. 1, 2*. 1937.

Azeredo-Penna, L. de. Floracao de Inverno. Rodriguesia **2**[9]: 107–111. 1937.

Azevedo, N. Replacao bibliographica referente a fungos e doencas do cafeeiro. Rodriguesia **2**: (Spec. No.) 213–238. 1936.

Beilmann, A. P. The behavior of a basswood during an artificial windstorm. Missouri Bot. Gard. Bull. **26**: 50–56. F 1938.

Beilmann, A. P. The Chinese elm. Missouri Bot. Gard. Bull. **26**: 48–50. F 1938.

Benatar, R. Contribuicao ao estudo bibliographico de doencas da roseira. Rodriguesia **2**: (Spec. No.) 239–264. 1936.

Berry, E. W. A representative of the Olacaceae in the Eocene of southeastern North America. Torreya **38**: 5–7. Ja–F 1938.

Berry, E. W. Additional Miocene plants from Grand Coulee, Washington. Bull. Torrey Club **65**: 89–98. *f. 1–8*. F 1938.

Bitancourt, A. A. & Jenkins, A. E. Variacoes de *Elsinoe australis* Bitancourt e Jenkins. Rodriguesia **2**: (Spec. No.) 315–317. *f. 1*. 1936.

Blake, S. F. Two new Asteraceae from the Charleston Mountains, Nevada. Proc. Biol. Soc. Washington **51**: 7–10. 18 F 1938.

Blakeslee, A. F. & Avery, A. G. Methods of inducing doubling of chromosomes in plants. Jour. Heredity **28**: 393–411. *f. 1–11*. D 1937.

Borgmeier, T. A historia da "Flora Fluminensis." de Frei Vellosa. Rodriguesia **2**[9]: 77–96. 1937.

Boyle, L. W. & McKinney, H. H. Local virus infections in relation to leaf epidermal cells. Phytopathology **28**: 114–122. F 1938.

Braun-Blanquet, J. Plant Sociology. i–xviii, 1–439. *f. 1–180.* New York. McGraw-Hill Book Co. 1932.

Translated and edited by Fuller, G. D. and Conard, H. S.

Brierley, P. & McKay, M. B. Experiments with aphids as vectors of tulip breaking. Phytopathology **28:** 123–129. F 1938.

Brown, H. P. & Panshin, A. J. Identification of the commercial timbers of the United States, i–xxvi. 1–223. *f. 1–274. pl. 1–60.* New York, McGraw-Hill Book Co. 1934.

Brunel, J. Qu'est-ce que le *Spirulina vaginata* de Kaiser? Nat. Canadien **64:** 290–292. *f. 1–4.* N 1937.

Clark, W. G. Polar transport of auxin and electrical polarity in coleoptile of *Avena*. Plant Physiol. **12:** 737–754. *f. 1.* Jl 1937.

Clayton, E. E. & Gaines, J. G. Blue mold (downy mildew) disease of tobacco. U. S. Dept. Agr. Farm. Bull. 1799: 1–16. *f. 1–9.* Ja 1938.

Cleonique-Joseph, Frere. Sur quelques additions a la flore du Quebec. Nat. Canadien **64:** 254–258. O 1937.

Clute, W. N. Meaning of plant names. LXXIII. Rues and milkworts. Am. Bot. **44:** 10–17. Ja 1938.

Clute, W. N. The Christmas rose. Am. Bot. **44:** 1–4. *illust.* Ja 1938.

Coffman, F. A. & Stevens, H. Influence of certain oat varieties on their F_1 progeny. Jour. Am. Soc. Agron. **29:** 314–323. *f. 1–3.* Ap 1937.

Cook, M. T. Pioneers in the study of virus diseases of plants. Sci. Monthly **46:** 41–46. *illust.* Ja 1938.

Darrah, W. C. Fossil plants and evolution. Evolution **4:** 5, 6. Ja 1938.

Dayton, W. A. & others. Range plant handbook. *illust.* Forest Serv. U. S. Dept. Agr., Washington. 1937.

Dobzhansky, T. Genetics and the origin of species. i–xvi. 1–364. Columbia Univ. Press. 1937.

Drechsler, C. Two hyphomycetes parasitic on oospores of root-rotting oomycetes. Phytopathology **28:** 81–103. *f. 1–4.* F 1938.

Dunn, S. Value of the dye-adsorption test for predetermining the degree of hardiness. Plant Physiol. **12:** 869–874. Jl 1937.

Eastwood, A. Two new wallflowers. Leafl. West. Bot. **2:** 73, 74. Ja 1938.

Emmert, E. M. Application of the chlorate method for determining nitrogen to light, fluffy materials. Plant Physiol. **12:** 999–1001. O 1937.

Epling, C. Synopsis of the South American Labiatae. Part 3. Repert. Spec. Nov. Beih. **85:** 193–228. 15 S 1936.

Epling, C. The Labiatae of Bolivia. Revista Sudam. Bot. **4:** 21–53. Ja 1937.

Everett, T. H. Plant exploration in the Rockies. Hort. Soc. N. Y. Bull. **1937:** 6–8. D 1937.

Everett, T. H. Eine Titanenwurz blüht auf. Gartenschönheit **19:** 47–50. *illust.* F 1938.

Eyerdam, W. J. New records of noteworthy northwestern plants. Leafl. West. Bot. **2:** 78. Ja 1938.

Florell, V. H. Native grasslands in the Huron (South Dakota) area. Jour. Am. Soc. Agron. **29:** 403–411. *f. 1–6.* My 1937.

Fogg, J. M. *Lophotocarpus spongiosus* in Salem County, New Jersey. Bartonia **17:** 21, 22. 2 Ap 1936.

Forbes, R. D. "Mikes," a botanical engima. Sci. Monthly **46:** 32–40. *illust.* Ja 1938.

Foster, A. C. & Tatman, E. C. Environmental conditions influencing the development of tomato pockets or puffs. Plant Physiol. **12:** 875–880. Jl 1937.

Fries, R. E. Revision der Arten einiger Annonaceen-Gatungen. Acta Hort. Bergiani **12:** 221–228. *pl. 1–8. f. 1–11.* 1937.

Frye, T. C. Ferns of the northwest. 1–177. *f. 1–62.* Portland, Oregon. Metropolitan Press. 1934.

Fulling, E. H. Reliable evergreens for the northeastern states. Jour. N. Y. Bot. Gard. **39:** 36, 37. *illust.* F 1938.

Fulling, E. H. Some choice coniferous evergreens for ornamental planting. Jour. N. Y. Bot. Gard. **39:** 25–31. *illust.* F 1938.

Gates, F. C. Grasses in Kansas. Rep. Kansas Board Agr. **55:** 1–349. *f. 1–270.* 1937.

Giesen, H. Triuridaceae. *In* Engler, A. Pflanzenreich **104**(IV.18): 1–84. *f. 1–18.* 1938.

Glock, W. S. Principles and methods of tree-ring analysis. Carnegie Inst. Publ. **486:** 1–100. *pl. 1–14.* 15 S 1937.

Graham, E. H. Botanical studies in the Uinta Basin of Utah and Colorado. Ann. Carnegie Mus. **26:** 1–432. *pl. 1–13.* 1937.

Granick, S. Urease distribution in *Canavalia ensiformis.* Plant Physiol. **12:** 601–623. *f. 1–10.* Jl 1937.

Greathouse, G. A. & Stuart, N. W. Enzyme activity in cold-hardened and unhardened red clover. Plant Physiol. **12:** 685–702. Jl 1937.

Greenleaf, W. H. Induction of polyploidy in *Nicotiana.* Science II **86:** 565–566. 17 D 1937.

Howell, J. T. A collection of Douglas' western American plants—II. Leafl. West. Bot. **2**: 74–77. Ja 1938.

Howell, J. T. A new *Mimulus*. Leafl. West. Bot. **2**: 79, 80. Ja 1938.

Howell, J. T. New varieties of western plants—II. Leafl. West. Bot. **2**: 70, 71. Ja 1938.

Hrdlicka, A. Man and plants in Alaska. Science II **86**: 559–560. 17 D 1937.

Hume, H. H. The genus *Cooperia*. Bull. Torrey Club **65**: 79–87. 1 F 1938.

Johnston, I. M. Notes on some *Astragalus* species of Ecuador and Peru. Jour. Arnold Arbor. **19**: 88–96. Ja 1938.

Jump, J. A. A new fungus on *Ficus nitida* Thumb. Jour. Agr. Univ. Puerto Rico. **21**: 573, 574. O 1937.

Jump, J. A. A new disturbance of red pine. Science **87**: 138–139. 11 F 1938.

Kramer, P. J. Photoperiodic stimulation of growth by artificial light as a cause of winter killing. Plant Physiol. **12**: 881–883. Jl. 1937.

Krausche, K. K. & Gilbert, B. E. Increase of transpiration rates of tomato leaves due to copper sprays. Plant Physiol. **12**: 853–860. Jl 1937.

Krug, H. P. Fusarium como causador da murcha do algodoeiro. Rodriguesia **2**: (Spec. No.) 319–320. 1936.

La Fuze, H. H. Nutritional characteristics of certain wood-destroying fungi, *Polyporous betulinus* Fr., *Fomes pinicola* (Fr.) Cooke, and *Polystictus versicolor* Fr. Plant Physiol. **12**: 625–646. Jl 1937.

LeClerg, E. L. Further studies on the parasitism of *Rhizoctonia solani* on sugar beets. Phytopathology **28**: 152, 153. *f. 1.* F 1938.

Lemmon, W. P. A new gentian from Georgia. Bartonia **17**: 4. 2 Ap 1936.

Leukel, R. W. Studies on bunt, or stinking smut, of wheat and its control. U. S. Dep. Agr. Tech. Bull. 582: 1–47. N 1937.

Lillo, M. Catalogo de las Acantaceas Argentinas. Lilloa **1**: 21–66. *illust.* 1937.

Linsbauer, L. Fifty years of plant physiology in Austria. Plant Physiol. **12**: 565–569. Jl. 1937.

Loesener, T. Celastraceae novae vel minus cognoscundae. II. Notizbl. Bot. Gart. Berlin **13**: 215–226. 15 Jl 1936.

Lubimenko, V. N. Plant physiology in the U. S. S. R. Plant Physiol. **12**: 895–897. O 1937.

Lutman, B. F. Microbiology. i–x. 1–495. *f. 1–211.* New York, McGraw-Hill Book Co. 1929.

Marsh, G. Effect of temperature upon the inherent potential of *Valonia.* Carnegie Inst. Publ. **475:** 1–16. *f. 1–3.* O 1937.

Marsh, G. Proof of the flux equilibrium relation. Plant Physiol. **12:** 861–867. *f. 1–3.* Jl 1937.

Mathews, F. S. Familiar flowers of field and garden. i–xv. 1–310. *illust.* New York, D. Appleton-Century Co. 1937.

McLean, F. T. "Glad." gossip—I. Flower Grow. **25:** 133, 145. Mr 1938.

McLean, F. T. Trees in profile. Jour. N. Y. Bot. Gard. **38:** 274–280. *illust.* D 1937.

Mello Barreto, H. L. de. Quatro Lavoisieras novas. Bol. Mus. Nac. Rio de Janeiro **12**[1]**:** 57–72. *illust.* Mr 1936.

Merrill, E. D. New or noteworthy Indo-Chinese plants. Jour. Arnold Arbor. **19:** 21–70. *f. 1–3.* Ja 1938.

Merrill, E. D. Unrecorded plants from Kwangtung. IV. Lingnan Sci. Jour. **15:** 415–429. *f. 1.* 24 Jl 1936.

Merrill, E. D. & Perry, L. M. A synopsis of *Acmena* DC., a valid genus of the Myrtaceae. Jour. Arnold Arbor. **19:** 1–20. Ja 1938.

Miller, E. S. A precise method with detailed calibration for the determination of absorption coefficients; the quantitative measurement of the visible and ultraviolet absorption spectra of Alpha carotene, Beta carotene, and lycopene. Plant Physiol. **12:** 667–684. *f. 1–8.* Jl 1937.

Moldenke, H. N. A further supplement to Edition 3 of H. N. Moldenke's The observed flora of Watchung, N. J., and its immediate vicinity. 1. N. Y. Bot. Gard. 28 Au 1937.

Moreland, C. F. Leaf temperatures of sugar cane. Plant Physiol. **12:** 989–995. O 1937.

Muenscher, W. C. *Lilaea subulata* in Washington. Torreya **38:** 8. Ja–F 1938.

Muller, A. S. Tres especies de *Septobasidium* sobre *Citrus* em Minas Geraes. Rodriguesia **2:** (Spec. No.) 351–354. 1936.

Mundkür, B. B. Host range and identity of the smut causing root galls in the genus *Brassica.* Phytopathology **28:** 129–142. *f. 1–3.* F 1938.

Munz, P. A. Studies in Onagraceae XI. A revision of the genus *Gaura.* Bull. Torrey Club **65:** 105–122. *f. 1–18.* 1 F 1938.

Munz, P. A. Interesting western plants—I. Leafl. West. Bot. **2:** 65–70. *illust.* Ja 1938.

Otero, J. I. & Cook, M. T. A bibliography of mycology and phytopathology of Central and South America, Mexico and the West Indies. Univ. Puerto Rico Jour. Agr. **21:** 249–486. Jl 1937.

Palmer, E. J. Adventures in fern collecting. II. Am. Fern Jour. **26:** 136–139. O–D 1936.

Parker, D. Affinities of the flora of Indiana. I. Am. Midl. Nat. **17:** 700–724. *f. 1–113.* Jl 1936.

Parks, H. B. Valuable plants native to Texas. Texas Agr. Exp. Sta. Bull. **551:** 1–173. *f. 1.* Au 1937.

Parodi, L. R. Revision de las Gramíneas del genero *Tridens* de las flora Argentina. Rev. Argentina Agron. **4:** 258–272. *f. 1–4.* D 1937.

Parodi, L. R. Nota sobre la multiplicación vegetativa de (*Pterogyne nitens*). Rev. Argentina Agron. **4:** 305–307. *illust.* D 1937.

Parodi, L. R. La floración de *Phyllostachys aurea* en la Argentina. Rev. Argentina Agron. **4:** 307, 308. D 1937.

Parodi, L. R. Contribución al estudio de las Gramíneas del género (*Paspalum*) de las flora Uruguaya. Rev. Mus. Univ. Nac. La Plata **1:** 211–250. *f. 1–9.*+*pl. 1.* 1937.

Parodi, L. R. Una nueva especie de (*Paspalum*) de la flora Argentina. Notas. Mus. Univ. Nac. La Plata **2:** 101–104. *illust.* S 1937.

Perez Arbelaez, E. Plantas utiles de Colombia I. Bol. Agr. Bogota. (Suppl.) 1–172. *f. 1–116.* 1936.

Pickel, D. B. Lista das molestias e dos fungos parasitarios das plantas cultivadas em Pernambuco. Rodriguesia **2:** (Spec. No.) 207–212. 1936.

Piland, J. R. & Willis L. G. The stimulation of seedling plants by organic matter. Jour. Am. Soc. Agron. **29:** 324–331. *f. 1–5.* Ap 1937.

Porterfield, W. N. The Chinese water-chestnut, *Scirpus tuberosus.* Jour. N. Y. Bot. Gard. **39:** 32–38. *illust.* F 1938.

Potbury, S. S. The La Porte flora of Plumas County, California. Carnegie Inst. Publ. **465:** 29–81. *pl. 1–19.* 1937.

Pound, F. J. History and cultivation of the Tonka bean (*Dipteryx odorata*) with analysis of Trinidad, Venezuelan and Brazilian samples. Trop. Agr. **15:** 28–32. F 1938.

Prescott, G. W. A new species and a new variety of the algal genus *Vaucheria* De Candolle with notes on the genus. Trans. Am. Micros. Soc. **42:** 1–10. *pl. 1, 2.* Ja 1938.

Preston, R. D. The contents of the vessels of *Fraxinus americana* L., with respect to the ascent of sap. Ann. Bot. II[6]: 1–21. *f. 1–5.* Ja 1938.

Pritham, G. H. & Anderson, A. K. The carbon metabolism of *Fusarium lycopersici* on glucose. Jour. Agr. Res. **55:** 937–949. *f. 1–4.* 15 D 1937.

Pulle, A. Flora of Suriname. (Netherlands Guyana) **2**[1]**:** 337–400. 1937.

Hernandiaceae contributed by A. J. G. H. Kostermans, Sapindaceae by H. Uittien and Capparidaceae by J. C. Went.

Pulle, A. Flora of Suriname. (Netherlands Guyana) **3**[1]**:** 305–336. 1937.

Passifloraceae contributed by C. P. Killip and Ochnaceae by C. Wehlburg.

Pulle, A. Flora of Suriname. (Netherlands Guyana) **4:** 433–513. 1937.

Myrsinaceae contributed by Bottelier, additions and corrections of the following Apocynaceae by F. Markgraf, Convolvulaceae by S. J. Van Ooststroom, Loganiceae and Boraginaceae by H. Uittien, Rubiaceae by C. E. B. Bremekamp, Ericaceae and Campanulaceae by J. Lanjouw and Labiatae by A. Kostermans

Purpus, J. A. *Echinocereus pensilis* (K. Brandegee) J. A. Purpus. Kakteenkunde **12:** 180–182. *illust.* D 1937.

Puttemans, A. Relacão dos fungus e bacterias encontrados na batateira (*Solanum tuberosum* L.) Rodriguesia **2:** (Spec. No.) 265–302. 1936.

Puttemans, A. Reivindicação visando a denominacão scientifica da doença da batateira. Rodriguesia **2:** (Spec. No.) 341–350. 1936.

Raines, M. A. & Travis, C. W. Seasonal variation in elongation of young seedling radicles. Plant Physiol. **12:** 997, 998. O 1937.

Rehder, A. New species, varieties and combinations from the herbarium and the collections of the Arnold Arboretum. Jour. Arnold Arbor. **19:** 71–87. *pl. 217, 218.* Ja 1938.

Rost, E. C. *Opuntia Bigelovii* Engelmann. Desert **10:** 13. *illust.* Ja 1938.

Sanborn, E. I. The Comstock flora of west central Oregon. Carnegie Inst. Publ. **465:** 1–28. *pl. 1–10.* 1937.

Sandwith, N. Y. *Valeriana parnassiifolia* Sandwith. Hooker's Icon. Plant. **34:** *pl. 3349.* S 1937.

A new species from Argentina.

Schaffner, J. H. Stability and unstability of sexual conditions in *Morus alba.* Jour. Heredity **28:** 426, 427. D 1937.

Schroder, H. H. Kapok tree. Nature Mag. **31:** 170. *illust.* Mr 1938.

Schulz, W. G. A century of sugar pine. Nature Mag. **31:** 167–170. *illust.* Mr 1938.

Schweinfurth, C. New orchids from Central America. Harvard Univ. Bot. Mus. Leafl. **5**: 89–104. F 1938.

Schweinfurth, C. *Epidendrum pansamalae* Schlecter. Harvard Univ. Bot. Mus. Leafl. **5**: 144. 5 Mr 1938.

Sealy, J. R. *Hippeastrum Blumenavia* Amaryllidaceae. Curt. Bot. Mag. **160**: *pl. 9504. f. 1–4.* Ja 1938.

Sealy, J. R. *Senecio Tabacon* Compositae. Curt. Bot. Mag. **160**: *pl. 9512. f. 1, 2.* Ja 1938.

Shands, R. G. Longevity of *Gibberella saubinetii* and other fungi in barley kernels and its relation to the emetic effect. Phytopathology **27**: 749–762. *f. 1.* Jl 1937.

Shanor, L. Observations on the development and cytology of the sexual organs of *Thraustotheca clavata* (DeBary) Humph. Jour. Elisha Mitchell Sci. Soc. **53**: 119–136. *pl. 12, 13.* Jl 1937.

Skottsberg, C. Further remarks on Hawaiian Artemisiae. Bot. Mag. Japan **51**: 196–202. *f. 1–45.* My 1937.

Skvortzow, B. V. Diatoms from Lake Michigan—I. Am. Midl. Nat. **18**: 652–658. *pl. 1.* Jl 1937.

Sleeth, B. & Bidwell, C. B. *Polyporus hispidus* and a canker of oaks. Jour. Forestry **35**: 778–785. *f. 1, 2.* Au 1937.

Small, J. K. The jungles of Manhattan Island I. Jour. N. Y. Bot. Gard. **37**: 201–207. S 1936. II. **38**: 208–216. *f. 1–3.* S 1937.

Smith, A. H. Unusual agarics from Michigan. IV. Papers Michigan Acad. Sci. **22**: 215–223. *pl. 20–24+f. 7.* Je 1937.

Smith, E. L. The influence of light and carbon dioxide on photosynthesis. Jour. Gen. Physiol. **20**: 807–830. *f. 1–8.* 20 Jl 1937.

Smith, H. B. Number of stomata in *Phaseolus vulgaris* studied with the analysis of variance technique. Am. Jour. Bot. **24**: 384–387. Je 1937.

Smith, L. B. A new *Columnea* from Jamaica. Rhodora **39**: 275–276. *f. 1, 2.* Jl 1937.

Smock, R. M. Morphology of the flower and fruit of the Loquat. Hilgardia **10**: 615–632. *pl. 1–4+f. 1–5.* My 1937.

Spence, L. E. Root studies of important range plants of the Boise River watershed. Jour. Forestry **35**: 747–754. *f. 1.* Au 1937.

Sprague, R. New or noteworthy parasitic species of Fungi Imperfecti in Oregon. Mycologia **29**: 426–433. Jl–Au 1937.

Stahl, A. Estudios sobre la flora de Puerto Rico. Ed. II. **1**: 1–343; **2**: 1–165. Publ. Fed. Emerg. Relief Admin. Puerto Rico. 1936.

Standley, P. C. Three new plants from Texas and Mexico and some recent additions to the Texan flora. Am. Midl. Nat. **18**: 683–684. Jl 1937.

Stebbins, G. L. Two new species of *Lactuca* from tropical Africa. Bull. Jard. Bot. Bruxelles **14**: 223–226. *f. 19.* N 1936.

Steere, W. C. Mosses of the G. Allan Hancock Expedition of 1934, collected by Wm. R. Taylor. The Hancock Pacific Expeditions **3**[1]: 1–12. *pl. 1.* F 1936.

Stewart, L. M. Studies in the life history of *Nitella hyalina* Agardh. Jour. Elisha Mitchell Sci. Soc. **53**: 173–190. *pl. 16–19+f. 1.* Jl 1937.

Svenson, H. K. Monographic studies in the genus *Eleocharis*. IV. Rhodora **39**: 210–231. Je 1937; 236–273. *pl. 460–465.* Jl 1937.

Swezey, A. W. Cactus anatomy. Desert **9**: 87–89, 94–95. *illust.* Au 1937.

Taubenhaus, J. J. & Watkins, G. M. *Phymatotrichum silvicolum* n. sp.: its structure and development. Am. Jour. Bot. **24**: 387–390. *f. 1–22.* Je 1937.

Taylor, C. F. & Blodgett, F. M. Control of a wilt disease of potato by formaldehyde dust. Am. Potato Jour. **14**: 154–157. My 1937.

Taylor, W. R. Notes on north Atlantic marine algae. I. Papers Michigan Acad. Sci. **22**: 225–233. *pl. 25–27.* Je 1937.

Tehon, L. R. Notes on the parasitic fungi of Illinois—VI. Mycologia **29**: 434–446. *f. 1–9.* Jl–Au 1937.

Thomas, H. E. Apple mosaic. Hilgardia **10**: 581–588. *f. 1–3.* My 1937.

Thomas, W. S. The beefsteak mushroom. Jour. N. Y. Bot. Gard. **38**: 201–207. *illust.* S 1937.

Thornberry, H. H. & Anderson, H. W. Some bacterial diseases of plants in Illinois. Phytopathology **27**: 946–949. S 1937.

Tompkins, C. M. A transmissible mosaic disease of cauliflower. Jour. Agr. Res. **55**: 33–46. *f. 1–5.* 1 Jl 1937.

Tompkins, C. M. & Tucker, C. M. *Phytophthora* rot of honeydew melon. Jour. Agr. Res. **54**: 933–944. *f. 1–4.* 15 Je 1937.

Torres, J. P. Some notes on avocado flower. Philippine Jour. Agr. **7**: 207–227. 1936.

Torrey, R. H. Botanizing in the Shickshock mountains of Gaspé, Quebec. Torreya **37**: 73–79. Jl–Au 1937.

Tschudy, R. H. Experimental morphology of some species of *Chaetomium*. I. Use of cultural reactions in determining species characteristics. Am. Jour. Bot. **24**: 472–480. *f. 1–15.* Jl 1937.

Tullis, E. C. & Cralley, E. M. Laboratory and field studies on the development and control of stem rot of rice. Univ. Arkansas Agr. Exp. Sta. Bull. 295: 1–23. *f. 1–6.* D 1933.

Ullstrup, A. J. Histological studies on wilt of China aster. Phytopathology **27**: 737–748. *f. 1–5.* Jl 1937.

Uphof, J. C. T. Sarraceniaceae. Natür. Pflanzenfamilien Ed. 2. 17[b]: 704–727. *f. 437–452.* 1936.

Ware, J. O. Genetic relations of nankeen lint to plant color and leaf shape in upland cotton. Univ. Arkansas Agr. Exp. Sta. Bull. 300: 1–44. My 1934.

Ware, J. O. Genetic relations of red plant color, leaf shape and fibre colors in upland cotton. Univ. Arkansas Agr. Exp. Sta. Bull. 294: 1–60. Je 1933.

Warmke, H. E. Cytology of the Pacific coast trilliums. Am. Jour. Bot. **24**: 376–383. *f. 1–24.* Je 1937.

Watkins, G. M. & Muller, C. H. An occurrence of *Sphaerotheca lanestris* in Mexico. Am. Midl. Nat. **18**: 659–660. *f. 1.* Jl 1937.

Watkins, J. V. Experiments with hormodin on tropical and semi-tropical plants. Florists Exch. **89**[3]: 20, 36. *f. 1–4* 17 Jl 1937.

Weimer, J. L. Effect of the dwarf disease on the alfalfa plant. Jour. Agr. Res. **55**: 87–104. *f. 1–10.* 15 Jl 1937.

Wells, B. W. Southern Appalachian grass balds. Jour. Elisha Mitchell Sci. Soc. **53**: 1–26. *pl. 1–5+f. 1, 13.* Jl 1937.

Went, F. W. Salt accumulation and polar transport of plant hormones. Science II. **86**: 127–128. *f. 1.* 6 Au 1937.

Werdermann, E. *Borzicactus aurivillus* (K. Schumann) Britton et Rose. Blüh. Sukkul. 31: *pl. 122.* 10 Ap 1937.

Werdermann, E. *Cochemiea setispina* (Coulter) Walton. Blüh. Sukkul. **32**: *pl. 126.* 15 Je 1937.

Werdermann, E. *Echinocereus pensilis* (K. Branegee) J. A. Purpus. Blüh. Sukkul. **31**: *pl. 121.* 10 Ap 1937.

Werdermann, E. *Lemaireocereus Beneckei* (Ehrenberg) Britton et Rose. Blüh. Sukkul. **32**: *pl. 125.* 15 Je 1937.

Werdermann, E. *Parodia aureispina* Backeberg. Blüh. Sukkul. **32**: *pl. 127.* 15 Je 1937.

Werdermann, E. *Rebutia* (*Aylostera*) *pseudodeminuta* Backeberg. Blüh. Sukkul. **32**: *pl. 128.* 15 Je 1937.

Werdermann, E. *Rebutia Marsoneri* Werdermann. Blüh. Sukkul. **31**: *pl. 123.* 10 Ap 1937.

Werdermann, E. Zwei seltene *Cochemiea*-Arten. Kakteenkunde **7**: 105–108. *illust.* Jl 1937.

Wheeler, L. C. *Euphorbia* in the Pacific states. Bull. So. California Acad. Sci. **35**: 127–147. My–Au 1936.

Wherry, E. T. A variety of *Phlox ovata* from the Alabama mountains. Bartonia **16**: 112–120. *pl. 2, 3.* 1934.

Wherry, E. T. Synonyms and variety names for *Phlox nivalis*. Gard. Chron. Am. **41**: 212–213. Jl 1937.

Wherry, E. T. The genus *Heuchera* in Virginia. Claytonia **4**: 3–6. Jl. 1937.

Wherry, E. T. The Polemoniaceae of Pennsylvania. Proc. Pennsylvania Acad. Sci. **9**: 150–155. *f. 1, 2.* 1935.

Whitaker, D. M. & Lowrance, E. W. The effect of hydrogen ion concentration upon the induction of polarity in *Fucus* eggs. Jour. Gen. Physiol. **21**: 57–70. *f. 1–3.* 20 S 1937.

White, D. Fossil flora of the Wedington sandstone member of the Fayetteville shale. U. S. Dep. Int. Prof. Paper 186-B: 13–41. *pl. 4–9.* 1936.

White, D. Fossil plants from the Stanley shale and Jackfork sandstone in southeastern Oklahoma and western Arkansas. U. S. Dep. Int. Prof. Paper 186-C: 43–67. *pl. 10–14.* 1936.

Whitney, L. D. A new species of Hawaiian *Eragrostis*. Bernice P. Bishop Mus. Occ. Papers **13**: 75–76. *f. 1.* 17 My 1937.

Wiegand, K. M. & Weatherby, C. A. The nomenclature of the verticillate *Eupatoria*. Rhodora **39**: 297–306. *pl. 466–468.* Au 1937.

Williams, L. O. Orchid studies. I. Harvard Univ. Bot. Mus. Leafl. **5**: 31–32. 1 Jl 1937.

Williams, L. O. The Orchidaceae of the Rocky Mountains. Am. Midl. Nat. **18**: 830–841. S 1937.

Willison, R. S. Peach canker investigations. III. Further notes on incidence, contributing factors, and related phenomena. Canadian Jour. Res. **15**: 324–339. *f. 1–5.* Jl 1937.

Wilson, P. W. Symbiotic nitrogen-fixation by the Leguminosae. Bot. Rev. **3**: 365–399. Au 1937.

Winkler, A. J. & Shemsettin, E. M. Fruit-bud and flower formation in the Sultanina grape. Hilgardia **10**: 589–610. *pl. 1–5.* My 1937.

Woodcock, E. F. Vegetative anatomy of the tomato (*Lycopersicum esculentum* Mill.) II. Leaf structure. Papers Michigan Acad. Sci. **22**: 235–242. *pl. 28–30+f. 8.* Je 1937.

Woods, M. W. & Bamford, R. Chromosome morphology and number in *Tulipa*. Am. Jour. Bot. **24**: 175–184. *pl. 1, 2+f. 1* Ap 1937.

Yamamoto, Y. Species nova Mitrastemonacearum (Rafflesiaceaeum) ex Mexico. Bot. Mag. Tokyo **50**: 539–541. *f. 1–7.* O 1936.

Yarwood, C. E. Sulphur and rosin as downy mildew fungicides. Phytopathology **27**: 931–941. *f. 1, 2.* S 1937.

CARRIED OVER FROM PREVIOUS ISSUE

Rombouts, J. Algunas palavras sobre uma molestia cryptogamica, prejudicial aos tomateiros, na Bahia, causada por *Septoria lycopersici* Speg. Rodriguesia **2**: 45–49. *f. 1, 2.* O 1937.

Saeger, A. C. The concentration of copper in nutrient solutions for *Spirodela polyrrhiza*. Am. Jour. Bot. **24**: 640–643. *pl. 1.* N 1937.

St. John, H. & Fosberg, F. R. Vegetation of Flint Island, central Pacific. B. P. Bishop Mus. Occ. Papers 12^{24}. 1–4. 5 Ja 1937.

St. John, H. & Warren, F. A. The plants of Mount Rainier National Park, Washington. Am. Midl. Nat. **18**: 952–985. N 1937.

Satina, S. & Blakeslee, A. F. Chromosome behavior in triploid *Datura*. II. The female gametophyte. Am. Jour. Bot. **24**: 621–627. *f. 1–16.* N 1937.

Schaffner, J. H. The fundamental nature of the flower. Bull. Torrey Club **64**: 569–582. *pl. 12, 13.* 9 D 1937.

Scheer, B. A. Straight growth of the *Avena* coleoptile in relation to different concentrations of certain organic acids and their potassium salts. Am. Jour. Bot. **24**: 559–565. *f. 1–5.* N 1937.

Schultes, R. E. Peyote (*Laphophora Williamsii*) and plants confused with it. Harvard Univ. Bot. Mus. Leafl. **5**: 61–88. *f. 1, 2.* 19 N 1937.

Schultz, E. S. Pathological phases of potato wart disease. Jour. Econ. Entom. **30**: 721–723. O 1937.

Sharnel, A. D. A large-fruited bud mutation of the winter Nelis pear. Jour. Heredity **28**: 351, 352. *f. 10.* O 1937.

Shreve, F. Lowland vegetation of Sinaloa. Bull. Torrey Club **64**: 605–613. *f. 1–3.* 9 D 1937.

Shull, A. F. "Germ track" and "germ tract." Science II. **86**: 440, 441. 12 N 1937.

Simmons, P. M. & Ledingham, R. J. A study of the fungous flora of wheat roots. Sci. Agr. Canada **18**: 49–59. *f. 1, 2.* O 1937.

Small, J. K. *Amsonia rigida.* Addisonia **20**: 25, 26. *pl. 653* 15 N 1937.

Smith, C. O. Inoculation of some economic plants with *Phytophthora cactorum* and *P. citrophthora*. Phytopathology **27**: 1106–1109. *f. 1.* N 1937.

Smith, E. I. The induction period in photosynthesis. Jour. Genl. Physiol. **21**: 151–163. *f. 1–5.* 20 N 1937.